ROOF WATER-FARM

A Multidisciplinary Approach to Integrate Wastewater Reuse with Urban Agriculture

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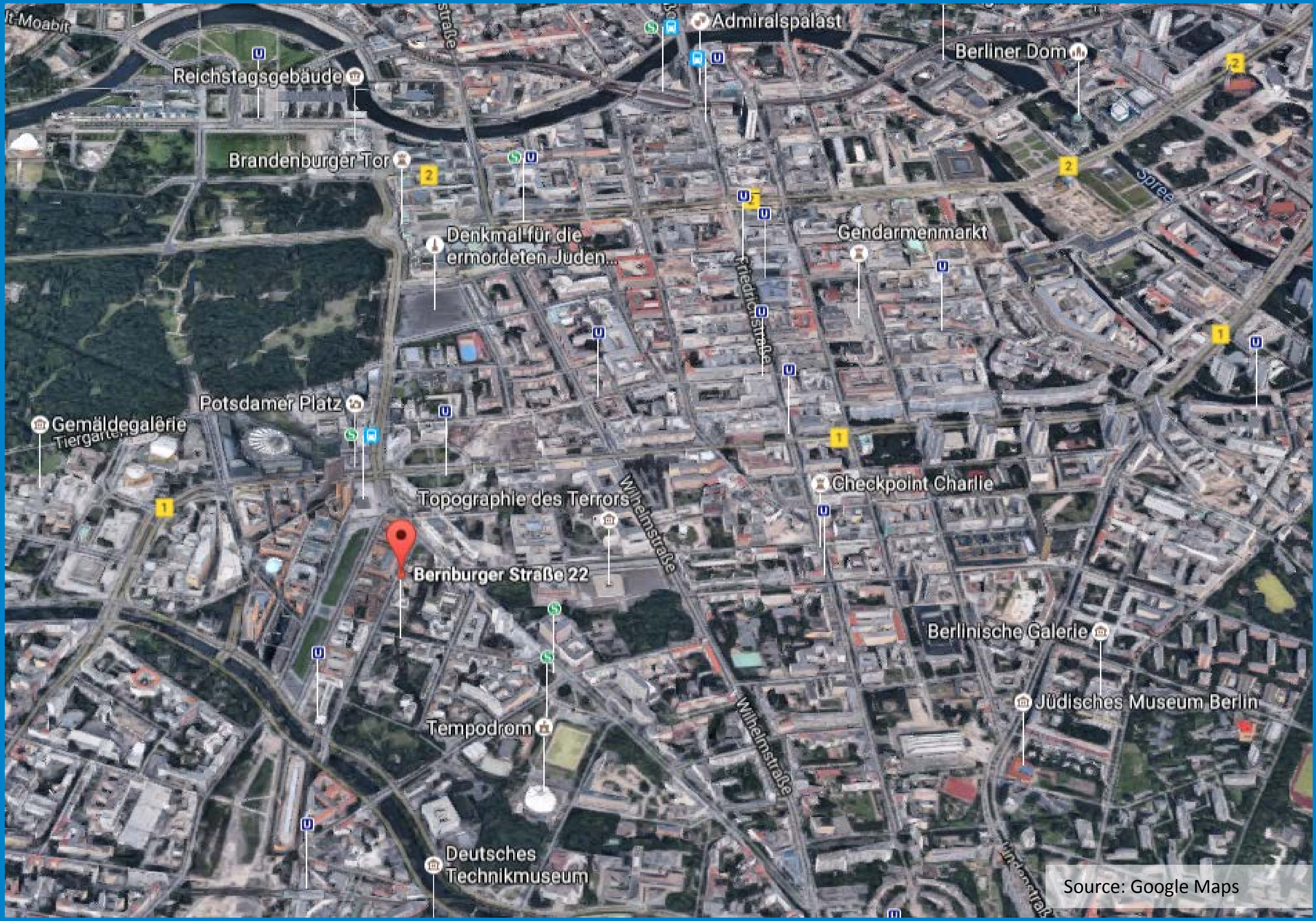

GOAL OF THE CALL:

Smart and Mulitifunctional Infrastructural Systems for Sustainable Water Supply, Sanitation and Stormwater Management

Funded by:

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Smart and Multifunctional Infrastructural Systems for Sustainable Water Supply, Sanitation and Stormwater Management

Project partners:

ROOF WATER FARM

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Duration: 01.07.2013 – 30.10.2017

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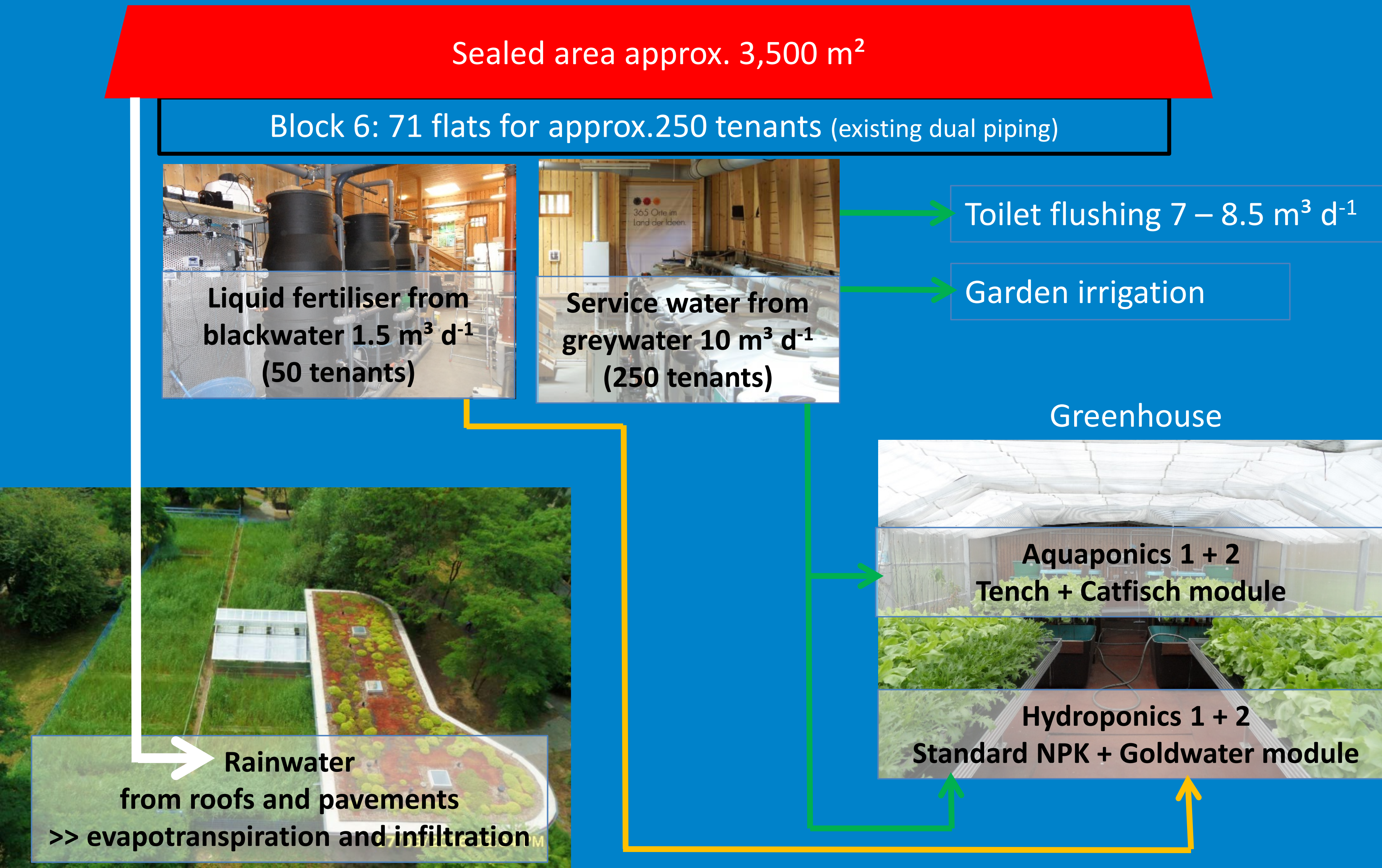
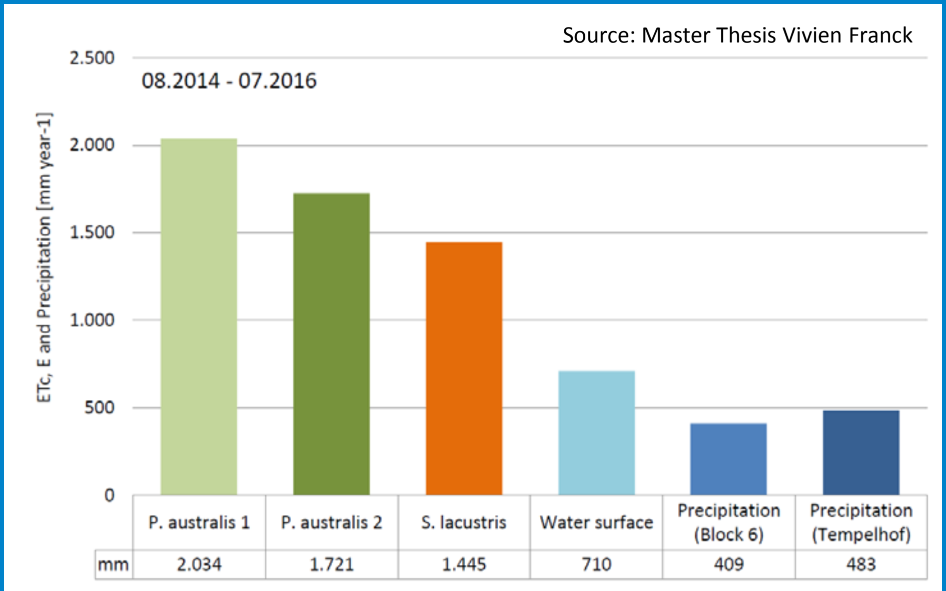
Roof Water-Farm Project



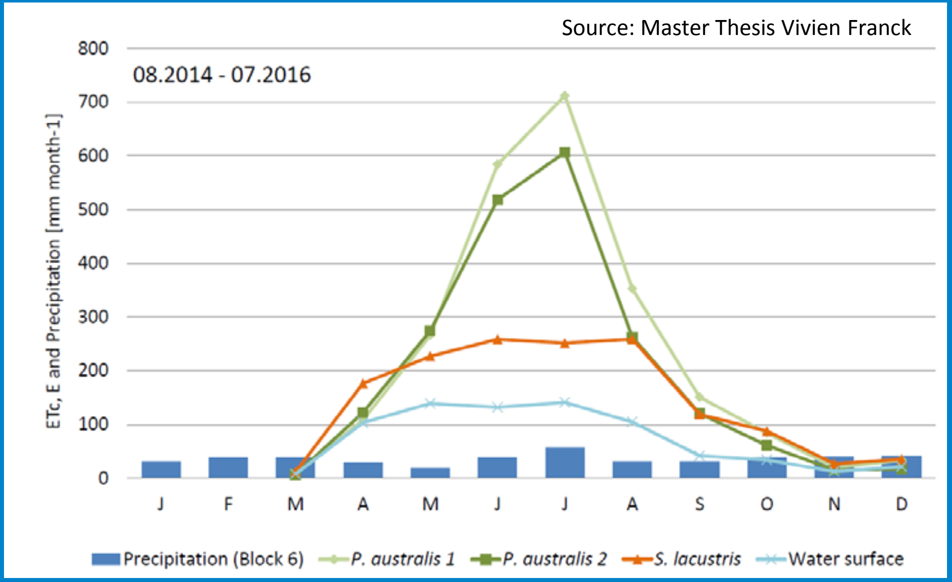
STORMWATER MANAGEMENT BY EVAPOTRANSPIRATION



- Disconnection of 3,500 m² of sealed area from the combined sewer

- Storage and evapotranspiration by means of an already exisitng 1,000 m² constructed wetland (cooling effect)

- Overflow is infiltrated (swale)



Wastewater - don´t mix it!

<u>Dilution is no solution!</u>

Wastewater:

1. avoid and reduce
2. recycle
3. disposal/dumping - as little as possible

The conventional water and wastewater sectors are the biggest communal consumers of electricity and resource-inefficient

Wastewater is a resource !!

		Wastewater (total)	Urine	Faeces	Blackwater incl. 30 L fushing water	Greywater
Amount	Litres	140	1.0%	0.1%	22.6%	77.4%
CSB	g/c/d	120	8.5%	51.3%	59.8%	40.2%
N		12.9	80.6%	11.6%	92.2%	7.8%
P		2.0	50.0%	25.0%	75.0%	25.0%
K		4.2	59.5%	16.7%	76.2%	23.8%
S		3.8	19.4%	5.6%	25.0%	80.6%

– Potential of biogas production from wastewater is (only) 118 Wh/c/d

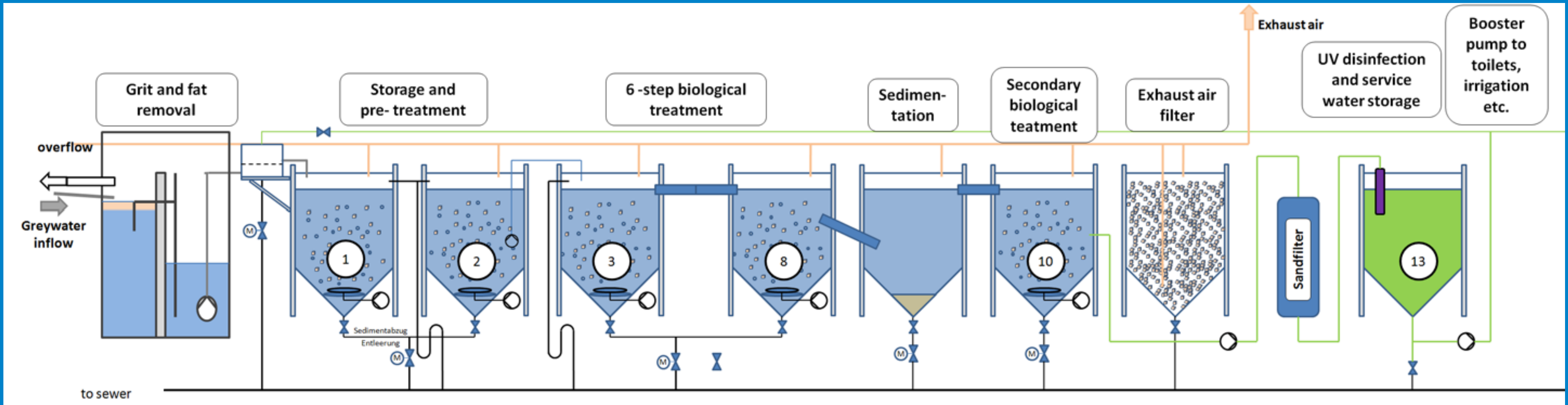
– Recycling potential of heat energy from wastewater is 243 Wh/c/d (cooling 1.5K)

✓ Recycling potential of nutrients (N, P, K) from wastewater is 75 - 92%

✓ Water saving potential from greywater is 75%

✓ Heat energy recovery potential from warm greywater is 1,754 Wh/c/d (cooling 14K)

GREYWATER (INCLUDING KITCHEN AND LAUNDRY WW)



HRT: 26 hrs

		Greywater System		Municipal WWTP **	
Parameter	**Unit**	**Influent***	**Effluent**	**Influent**	**Effluent**
TSS	mg L^{-1}	113	< 0.1	387	5.8
Turbidity	NTU		< 1		
BOD_5	mg L^{-1}	460	< 5	218	3.8
COD	mg L^{-1}	858	25	610	40
DOC	mg L^{-1}		7 - 10	54	12,2
TN	mg L^{-1}	16.2		72	11.7
NH_4-N	mg L^{-1}	2.7	< 0.03	45	0.9
NO_3-N	mg L^{-1}		3.5		6.9
TP	mg L^{-1}	4.7		16	0.3
PO_4-P	mg L^{-1}	1.6	1.5		0.09
E. coli	1/100 ml		< 10^1		10^4 - 10^5

<u>Heavy metals:</u>
Concentrations of heavy metals in treated greywater are in the range of drinking water requirements.

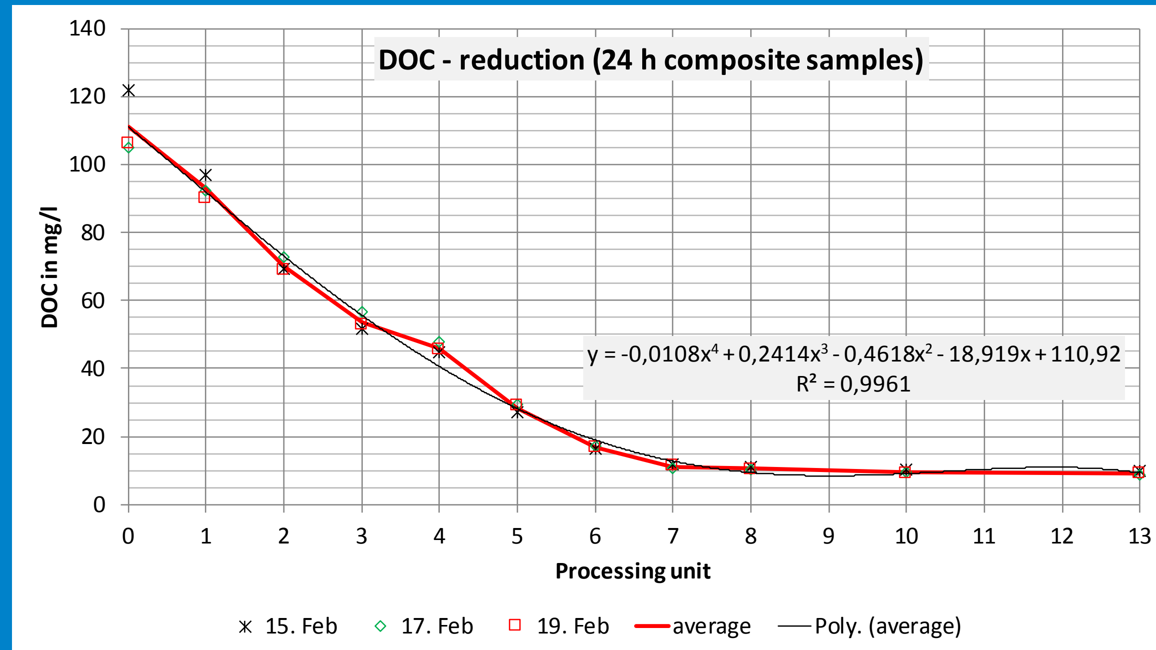
<u>Micropollutants:</u>
Several micropollutants (contrast agents, pain killers, beta blockers etc.) where not detected or found at very low concentrations.

Others, like Acesulfam (sweetener) or Diclofenac were reduced to significantly lower levels than those measured in communal wastewater effluents.

Sources: * Sievers et al., 2014
** Bahr et al., 2007 & BWB, 2016

Micropollutants and organic compounds in greywater and service water

4-Formylamino-antipyrin	Bezafibrat	Atenolol
LoQ 0.1	LoQ 0.05	LoQ 0.1
n.n.	n.n.	n.n.
WW: ??	**WW: 0.28**	**WW: ??**
Sulfmethoxazol	**Primidon**	**Valsartan**
LoQ 0.05	LoQ 0.5	LoQ 0.1
WW: 0.25	**WW: 0.35**	**WW: 8.6**
n.n.	n.n.	n.n.
Amidotrizoe-säure	**Mecoprop**	**Iomeprol**
LoQ 0.1	LoQ 0.05	LoQ 0.1
WW: 1.8	**WW: 0.04**	**WW: 2.2**
n.n.	n.n.	<LoQ
Venlafaxin	**Iopromid**	
LoQ 0.05	LoQ 0.1	
WW: ??	**WW: 0.16**	
n.n.	<LoQ	



Stage of biological treatment	Acesulfam	Benzotriazol	Carbamazepin	Gabapentin	Gabapentin-Lactam	Methylbenzo-triazol	Metoprolol	Diclofenac
	LoQ 0.25 µg/l	LoQ 0.1 µg/l	LoQ 0.05 µg/l	LoQ 0.05 µg/l	LoQ 0.05 µg/l	LoQ 0.05 µg/l	LoQ 0.01 µg/l	LoQ 0.1 µg/l
SW	1.29	17.36	0.15	0.28	0.21	0.88	0.35	0.67
R 9	2.38	14.38	0.22	0.32	0.23	0.90	0.28	1.05
R 8	2.07	17.10	0.17	0.33	0.19	0.94	0.34	1.33
R 7	2.87	19.97	0.22	0.44	0.14	1.06	0.31	1.73
R 6	11.89	24.85	0.19	0.52	0.08	1.39	0.46	1.87
R 5	10.70	21.55	0.16	0.62	0.11	1.16	0.41	1.57
R 4	11.94	20.68	0.17	0.58	0.09	0.72	0.34	2.41
R 3	15.99	25.75	0.15	0.57	0.07	0.58	0.45	1.95
R 2	18.68	24.41	0.18	0.59	0.08	0.40	0.43	1.99
R 1	16.57	22.77	0.18	0.64	0.10	0.38	0.35	3.17
Influent	14.20	20.02	0.20	0.59	0.09	0.37	0.25	3.11
Effl. WW	**14.00**	**12.00**	**2.96**	**8.31**	**0.49**	**3.20**	**4.16**	**4.18**

Red numbers:
average for WWTP effluents in Berlin

GREYWATER

Economy

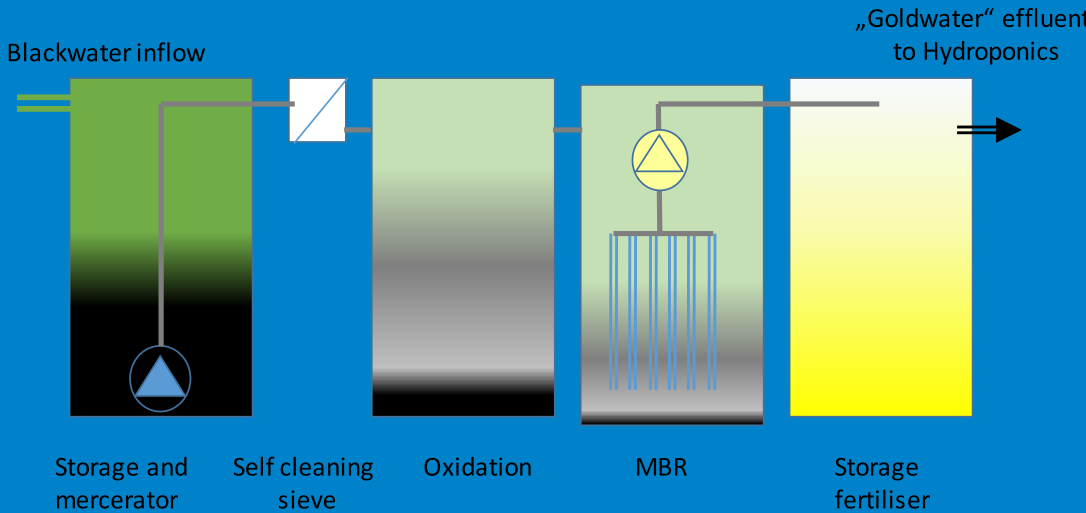
Investment:
Dual piping network approx. 500 €/apartment
Treatment plant: approx. 500 €/c

Water savings:
30 - 60 litres/c/d (50 - 100 €/c/a)

Price of service water:
< 3 €/m³ incl. investment, maintenance/operation
(drinking water incl. WW in Berlin approx. 5€/m³)

- Water and energy recycling can reduce investment and running costs:
  Connection to the sewer (Berlin 2014) approx.
  24,000 € per unit (average 3.5 persons per household)

Blackwater (from approx. 50 Persons)



		undiluted				urine + faeces + 30 L toilet flushing water			
		Urine		Faeces		Blackwater		Block 6	
			mg l^{-1}		mg l^{-1}		mg l^{-1}	mg l^{-1}	%
Quantity	L P^{-1} d^{-1}	1.37		0.14		31.5			
COD	g P^{-1} d^{-1}	10	7,299	60	428,571	70	2,222	**1,929**	**86.8**
N	g P^{-1} d^{-1}	10.4	7,591	1.5	10,714	11.9	378	**283**	**74.9**
P	g P^{-1} d^{-1}	1.0	730	0.5	3,571	1.5	48	**32**	**66.5**
K	g P^{-1} d^{-1}	2.5	1,824	0.7	5,000	3.2	102		
S	g P^{-1} d^{-1}	0.7	511	0.2	1,429	0.9	29		

		E. coli per 100ml	Enterococci per 100ml
Greywater influent		$7.5x10^5$ - $1.4x10^6$	$5.5x10^3$ - $4x10^4$
Service water		2 - 3	0
Blackwater influent		$7x10^8$	$1.95x10^7$
Liquid fertiliser from blackwater		2	0
Effluent of municipal WWTP (Berlin)		10^4 - 10^5	10^3 – 10^4

Aquaponics and Hydroponics

Goal of the research is to compare product qualities, not to optimise production

- Quality of service water from greywater recycling is better than water in Berlin lakes and ponds (BOD, heavy metals, bacteria, MPs)
- RWF food products are safe. Tested MPs did not accumulate in the products
- The hygienic product quality of fish and vegetables always fulfills the strict German requirements of DGHM*.

*German Society for Hygiene & Microbiology

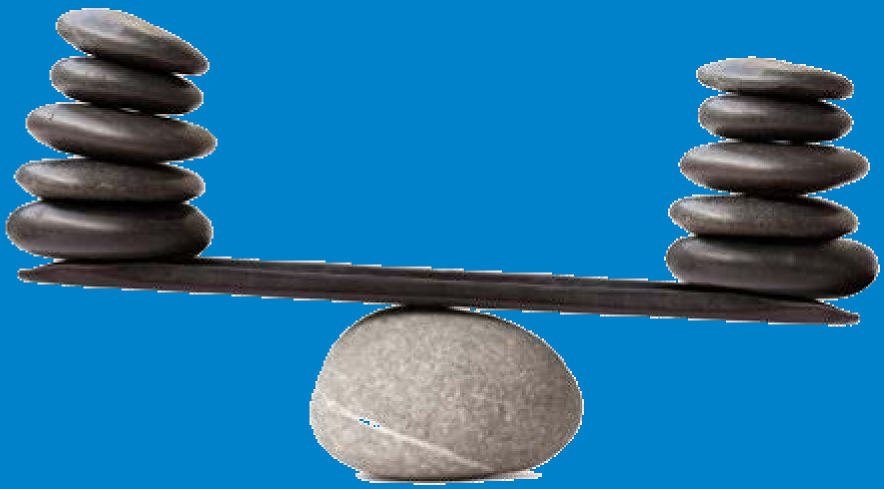
RWF - TECHNOLOGY

- Greywater recycling technology for high polluted greywater is „ready for use" - since years
- The potential of heat recovery from greywater should be used - it is also „ready for use"

- Liquid fertiliser from blackwater is shown to be safe and compatible for hydroponics systems
- The so-called „goldwater" is not yet certified
- Low maintenace solutions for extraneous material (textiles, plastic etc.) still have to be found

- Commercial greenhouses require cheap heat energy source (e.g. waste heat)
- Commercial food production with recycled wastewater is still subject to approval

For decision-making, monetary and non-monetary stones have to be allocated according to local needs:



Product life cycle

Safety at work

Resource efficiency

Demografic change

Cost efficiency

Comfort

Flexibility

Social aspects

Interference resistance

Carbon footprint

Complexity of planning processes

Payable rents

Running costs

Hygienic aspects

Environmental aspects

Qualification of staff

Finite nature and insecurity of phosphorus supply

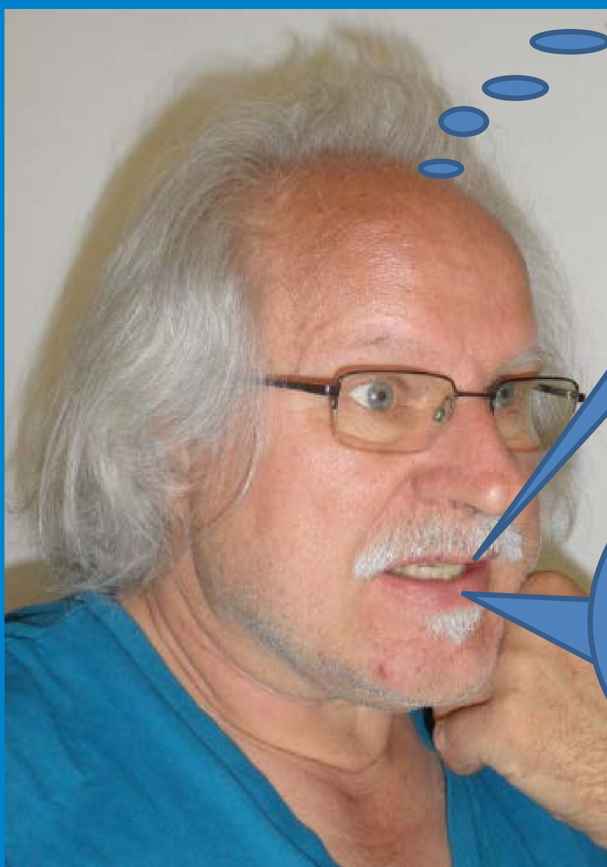
Surface water quality

Bureaucracy

Investment

Technical regulations

Conventional systems are
expensive and resource-inefficient.
Implementation of new infrastructure
and ecological water concepts needs courage,
perseverance, political will and backing.
Good luck!



Thank you for listening and for own thinking!

Wastewater is a valuable resource.
New sanitation concepts should be planned
together with local energy concepts.

PROVED AND TESTES SYSTEMS ARE AVAILABLE:
demonstrable for everyone; high quality products;
professional operation and maintenance; research;
public relations and marketing