

Neighborhood-Scale Urban Water Reclamation with Integrated Resource Recovery for Establishing Nexus City in Munich, Germany: Pipe Dream or Reality?

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Supplementary Materials:

Table S1. Project statistics in the neighborhood Jenfelder Au [3,4].

Parameter	Unit	Remarks
In operation since	October 2013	
Capacity	2,000 people	
Capital costs	7,810,000 €	
Operational costs	64,000 €/year (32 €/capita/year)	
Blackwater generated	12 m ³ /day	
Final sludge quantity	150 tons/year	
Expected biogas yields	340,000 m ³ /year	With added fat of around 9000 m ³ /year
Energy requirement	35.8 kWh _{el} /capita/year Plus 200 kWh _{th} /capita/year*	*As heating energy for the digester
Expected net electricity generation	339.7 kWh _{el} /capita/year	
Expected net heating generated	578 – 711 kWh _{th} /capita/year	With the use of sludge heat recovery

Table S2. Available project statistics in the neighborhood of Lanxmeer [5,6].

Parameter	Unit	Remarks
In operation since	1999	
Capacity	250 houses + hotel and conference center	
Slurry leaving the digester	5 m ³ /day	
Net electricity generation	81 kWh _{el} /day	
CO ₂ reduction overall	192 kg/house/year	

Table S3. Available project's statistics in the neighborhood of Flintenbreite [7].

Parameter	Unit	Remarks
In operation since	2002	
Capacity	117 apartments for 350-380 people	
Generated wastewater quantity	4.8 L/capita/day blackwater 56 L/capita/day greywater	
Electricity consumption	25 kWh _{el} /capita/year	For vacuum toilets
Capital cost	20 million €	
Cost of the treatment facility alone	600,000 €	40% higher than an equivalent conventional system, but operational costs expected to be 25% lower

Table S4. Available project's statistics in the neighborhood of Knittlingen [8].

Parameter	Unit	Remarks
In operation since	2009	
Capacity	100 apartments for 350 people	Currently around half of that number are living there (175) as of the last review (2010)

Theoretical biogas yield	80 L/capita/day or 28,000 L/day	With the addition of organic waste from kitchens using macerators
Current max biogas yield	8,000 L/day	5,000 L/day from the digester plus 3,000 L/day from the AnMBR. This value is for 175 people only
Expected flux	20 L/m ² /h	Flux in winter can go down to 12-14 L/m ² /h

Table S5. Project statistics in the neighborhood of Allermöhe [9].

Parameter	Unit	Remarks
In operation since	1986 (First stage)	
Capacity	36 single family houses, 140 people	
Water saved by using waterless toilets	40 L/capita/day	
Generated wastewater	82 L/capita/day	Compared to 128 L/capita/day in Munich (Van Houtte & Verbauwhede, 2012)
Treated Greywater quantity	3650 – 4,700 m ³ /year	
Cost of CWT construction	95,000 €	This was in 1983-1986 where the technology was in its infancy, expected prices today should be much lower
Area of the CWT for greywater treatment (Vertical CTW)	240 m ²	Amounts to around 1.7 m ² /capita, which is much lower than 2.5 m ² /capita typically required when no greywater separation is implemented
Expected annual cost savings	18,000 €/year (130 €/capita/year)	

Table S6. Summary of the current situation [11,26].

Parameter	Unit	Remarks
Capacity	3 million people	Two centralized treatment plants in Munich
Length of sewerage network	2413 km + 918 km*	*from extra syndicates
Cost of sewage disposal	1.56 €/m ³	
Cost of rainwater disposal in mixed network	1.3 €/m ²	Annual fee per surface area for rainwater
Costs for piping maintenance/expansion	192.3 million €	For projects starting from 2000 till 2021. However most spending is after 2015
Maintenance/ upgrades for treatment plants	288.45 million €	For projects starting from 2000 till 2021. However most spending is after 2015
Upgrades to dumping site	48 million €	* 2005 - 2017
Total costs for maintaining the current system	528.75 million €	In 20 years, so around 26.4375 Million €/year. For current population around 14.94 €/capita/year
Typical water consumption	128 L/capita/day, incl. 38 L for toilet flushing	*source: (SWM, 2015)
Total sewage discharge	165.5 million m ³ /year	in 2015
Dry sewage discharge	145.9 million m ³ /year	in 2015

Table S7. Demonstration plant statistics in Am Römerweg between Nov. 2009 and July 2010, the values between the brackets are the min and max values, the value outside the bracket is the average for the observed period [8].

Parameter	Influent	Effluent	Removal efficiency
COD [mg/L]	914 (425-1215)	135 (63.8-280)	85%

N _{total} [mg/L]	109 (77.5-151)	110 (76-135)	0%
NH ₄ -N [mg/L]	88 (55.8-127)	94.4(70.3-116)	0%
PO ₄ -P [mg/L]	13.1 (9.87-17)	12.6 (8.62-13.8)	0%
Total coliforms [CFU/ml]	1.5E7	5.8 (0-17)	99.99996%
E. coli [CFU/ml]	2.9E6	0	100%

Table S8. Results from the pilot project in the study of [12].

Parameter	Influent	Effluent	Removal efficiency
COD [mg/L]	425 ± 47	51 ± 10	88%
NH ₄ -N [mg/L]	32.4 ± 11.6	31.1 ± 12.3	0%
NO ₃ -N [mg/L]	1.3 ± 0.4	1.1 ± 0.6	0%
TP [mg/L]	4.3 ± 0.5	3.8 ± 0.7	0%
Turbidity [NTU]	38.7 ± 5.4	<0.3	>99%
TSS [mg/L]	294 ± 33	<0.8	>99.5
pH	7.6 ± 0.3	7.0 ± 0.2	-

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