How does greywater separation impact the operation of conventional wastewater treatment plants?

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7th Specialized Conference on Resources Oriented Sanitation

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Outline

- Problem definition and motivation
- Goals of the study
- Materials and methods
- Results and discussion
- Conclusions and outlook

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Problem definition and motivation

Why source-separated sanitation?

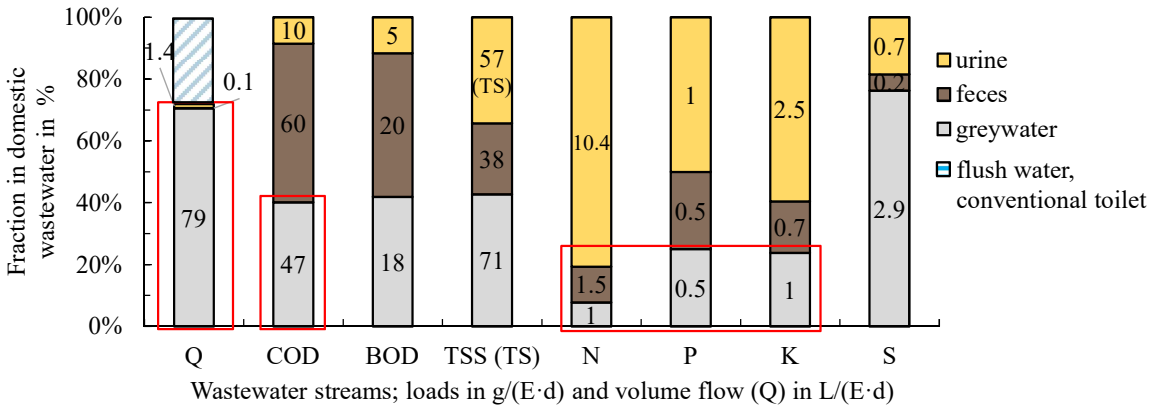

Fig 1. Inhabitant specific loads and volume flow in different wastewater streams
Source: WSWU, DWA (2016)

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Greywater modelling - Problems

- Up to now there is **not much statistically representative data for greywater**, especially not for low-strength greywater
- Water consumption - and thus **greywater production - varies from country to country**, according to cultural habits, climate conditions, water availability, economic status, environmental consciousness etc.
- The **variability** of concentrations, volume flows and temperature are much more **expressive** in **small units** than in large systems

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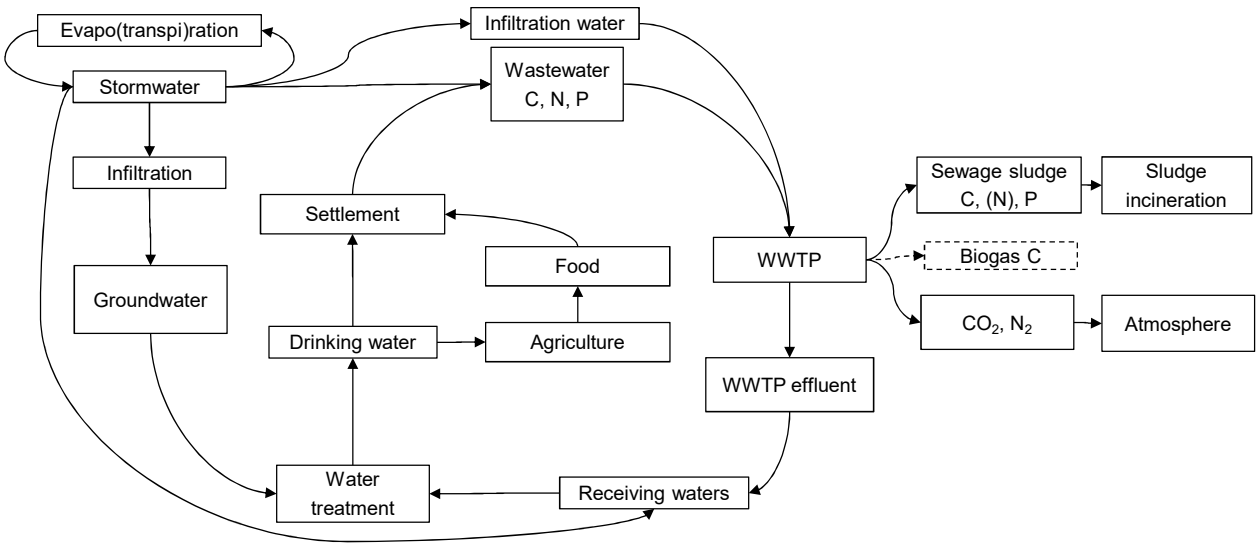
Conventional Urban Water Management



Source: modified from Mang, P. (2018): Influencing factors on the greywater treatment using soil filters. Bachelor's thesis, TU Kaiserslautern

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Resource-Oriented Urban Water Management

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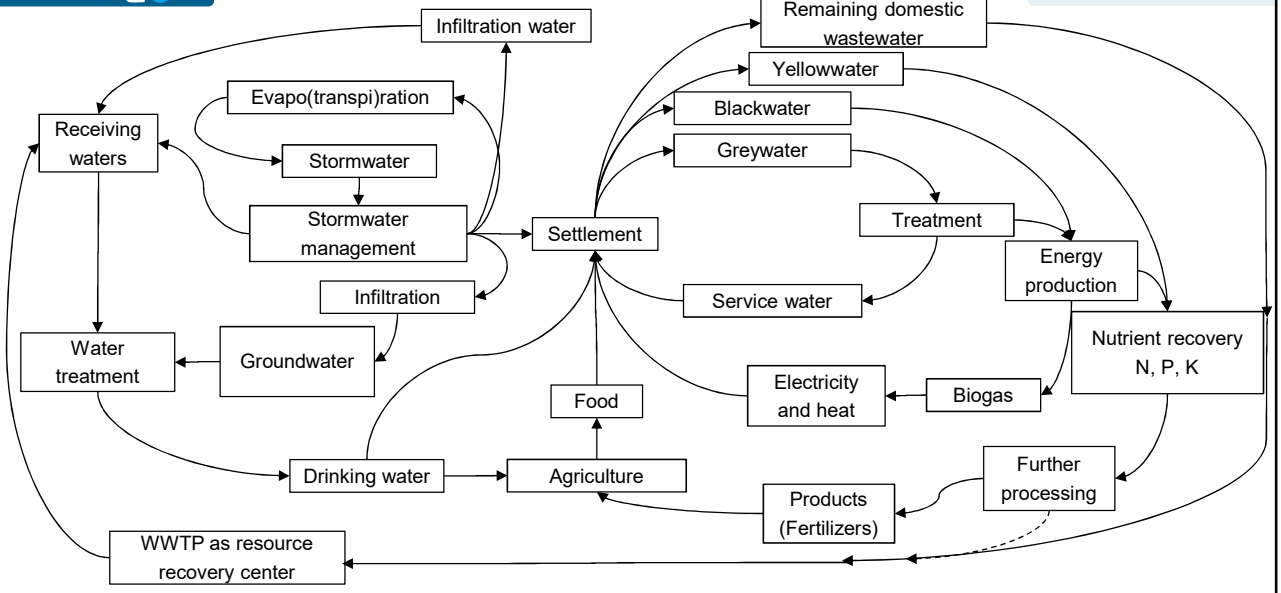

Source: modified from Mang, P. (2018): Influencing factors on the greywater treatment using soil filters, Bachelor's thesis. TU Kaiserslautern.

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Goals of the study

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- Is resource-oriented sanitation **only** to be addressed within the context of **decentralization in new development areas**?
- **Which role** will/can **WWTP** play in the future of the wastewater management?
- Is **resource-oriented sanitation compatible** with existing **centralized WWTP**?
- Which **benefits** and **drawbacks** can be expected for the WWTP **by separating greywater** from the main wastewater stream?
- How can **integrated approaches** (p.e. urine separation or blackwater co-digestion) **benefit greywater** separation from the plant?

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Materials and Methods

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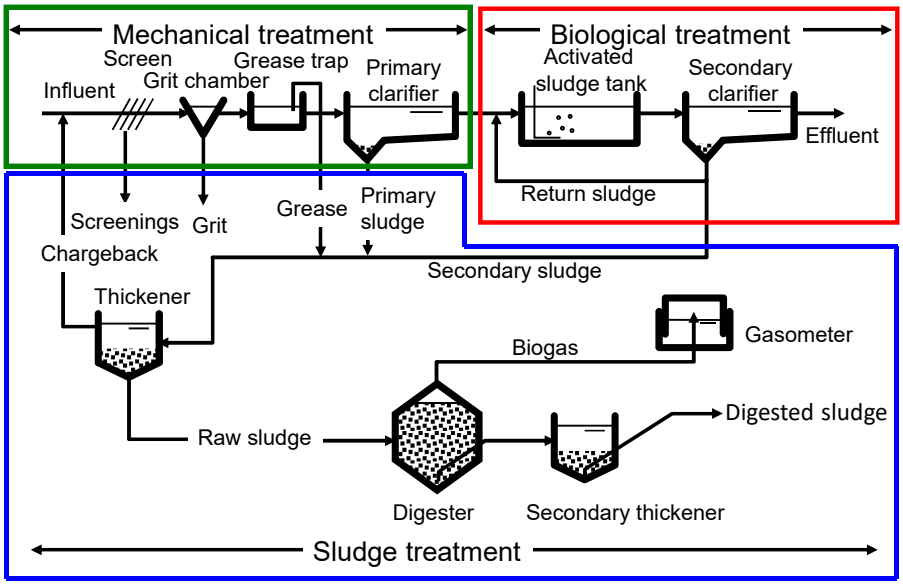

Source: modified from Gujer (2007): Siedlungswasserwirtschaft.

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Materials and Methods

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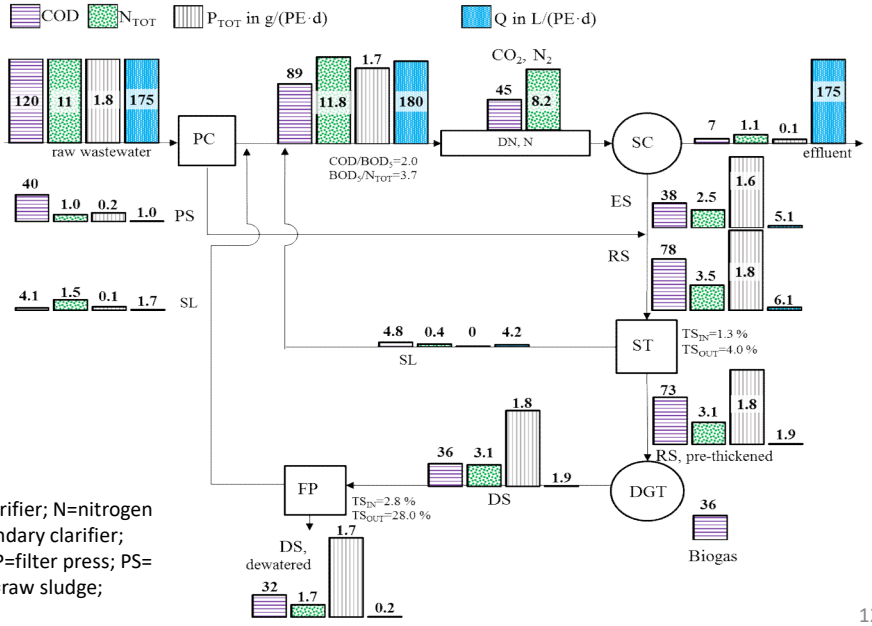
Actual state =
no greywater separation =
0 % transition



- with: Q= volume flow; PC=primary clarifier; N=nitrogen removal; DN=denitrification; SC=secondary clarifier; ST=sludge thickener; DGT=digester; FP=filter press; PS= primary sludge; ES=excess sludge; RS=raw sludge; DS=digested sludge; SL= sludge liquor.

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Outline

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Results and discussion

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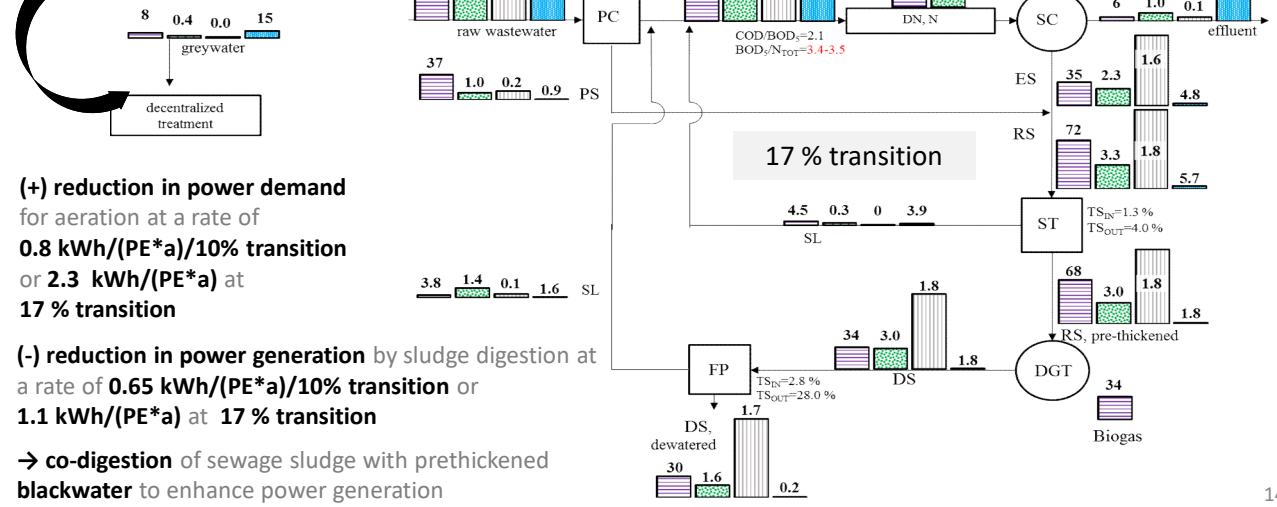
0-17% greywater separation =
0-17% transition



(+) reduction in power demand for aeration at a rate of **0.8 kWh/(PE*a)/10% transition** or **2.3 kWh/(PE*a)** at **17 % transition**

(-) reduction in power generation by sludge digestion at a rate of **0.65 kWh/(PE*a)/10% transition** or **1.1 kWh/(PE*a)** at **17 % transition**

→ **co-digestion** of sewage sludge with prethickened **blackwater** to enhance power generation

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Blackwater co-digestion in WWTP

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- Urban Water Management

URBAN WATER JOURNAL, 2017
http://dx.doi.org/10.1080/1573062X.2017.1301502
Taylor & Francis
RESEARCH ARTICLE

Impact of new sanitation technologies upon conventional wastewater infrastructures

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- **Blackwater co-digestion** can be **easily integrated into WWTP**
- **Blackwater thickening** was **required** in the short-term
- At **35 % blackwater separation** there was a gain of **11 kWh/(PE*a)** due to enhanced biogas production and aeration savings

- Desalination and Water Treatment

Impacts of blackwater co-digestion on biogas production in the municipal wastewater treatment sector using pilot-scale UASB and CSTR reactors

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- For CSTR operation, **higher methane yields** were achieved **with increasing blackwater fractions** at the reactor inlet
- **Blackwater co-digestion benefits** plant operation in terms of **biogas production**
- **Municipal digesters** can be successfully integrated in **transition strategies** for resource-oriented sanitation

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Results and discussion

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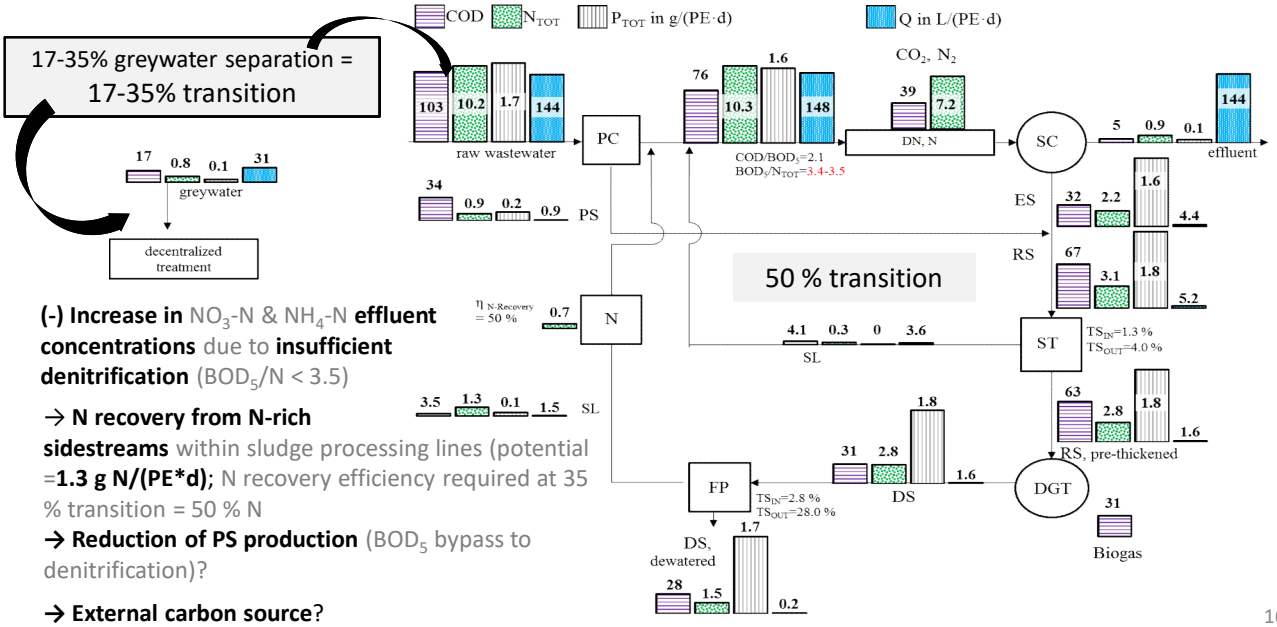
17-35% greywater separation = 17-35% transition



(-) Increase in NO_3-N & NH_4-N **effluent concentrations** due to **insufficient denitrification** ($BOD_5/N < 3.5$)

→ **N recovery from N-rich sidestreams** within sludge processing lines (potential =**1.3 g N/(PE*d)**; N recovery efficiency required at 35 % transition = 50 % N

→ **Reduction of PS production** (BOD_5 bypass to denitrification)?

→ **External carbon source**?

Results and discussion

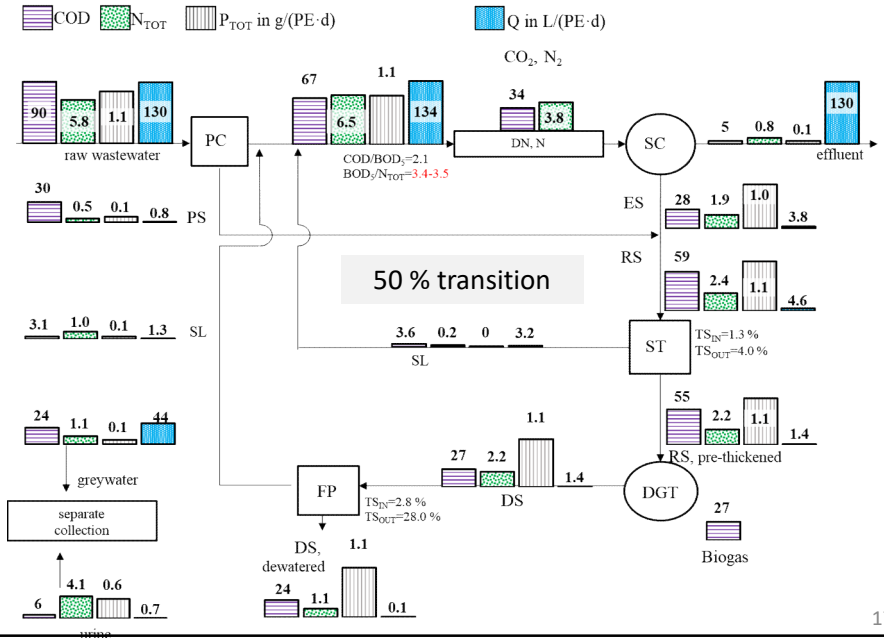
35-85% greywater separation = 35-85% transition

(-) Increase in NO_3-N & NH_4-N **effluent concentrations** due to **insufficient denitrification** ($BOD_5/N < 3.5$)

(+) Reduction in power demand for aeration of **1.4 kWh/(PE*a)/10% transition** or **7 kWh/(PE*a)** at **50% transition** by combined urine and greywater separation

→ **blackwater co-digestion** in WWTP?

→ major **mainstream process alternations**?



35-85 % transition II

→ Urine separation *y* required at a rate of ***y*[%] = 1.26 *x*[%] - 9.3**, with **x = greywater separation in %** to avoid problems in denitrification, e.g. **75 % greywater separation** requires **85 % urine separation**

→ Possibility of recovery N and P from both sludge liquor and urine at max. total rates of

0.087x + 0.800 g N/(PE*d) and

0.013x + 0.005 g P/(PE*d), with **x = greywater separation in %,** e.g. at **50 % transition: 5.15 g N/(PE*d)** and **0.66 g P/(PE*d)**

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Conclusions and Outlook

- The **integration of WWTP** in **transition concepts for resource-oriented sanitation** will be indispensable for the longer-term wastewater management
  - **Decentralized** and **centralized** approaches can be combined, while achiving **synergistic effects**
- **Greywater separation favors plant operation in the short to mid-term** up to 17 % transition, mainly under energy aspects
  - Yet **process implementations** e.g. within sludge processing lines (e.g. **N recovery from N-rich streams**) are required hereafter
- Additionally, extensive **mainstream process changeovers** (e.g. nitritation/anammox) **can be avoided in the mid-term**, if **urine is also separated** from the main wastewater stream

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Conclusions and outlook

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- The **integration of resource-oriented sanitation systems in WWTP** is promising, but must be carried out in accordance with the capabilities of existing infrastructures and precise examination of **specific boundary conditions**
- A **sensitivity analysis** may enhance the **reliability** of the results

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Thank you for your attention!

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