The Sanitation Challenge
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Separated grey- and blackwater treatment by the Komplett water recycling system

A possibility to close domestic water cycle

University of Kaiserslautern
Institute of Urban Water Management

Presentation Outline

- **Introduction**
- **Material & Methods**
  - greywater pilot plant
  - blackwater pilot plant
- **Results & Discussions**
  - purification efficiency of the pilot plants
  - comparison requirements for reuse
- **Summary & Outlook**

Background

- **project KOMPLETT funded by** Federal Ministry of Education and Research
- **alternative sanitation concept, which base on the aims of the recycling management**
  - separation of different wastewater flows
  - appropriate treatment
  - closed loop systems for water and nutrients

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Research Objectives

- **creation of a complete package, from in-house technology to automation, remote control technology and information system up to the utilization of the solids**
- **development of a key technology on base of the best available technology of different branches**
- **development of a self-sufficient, decentralized and intelligent high-tech-system with**

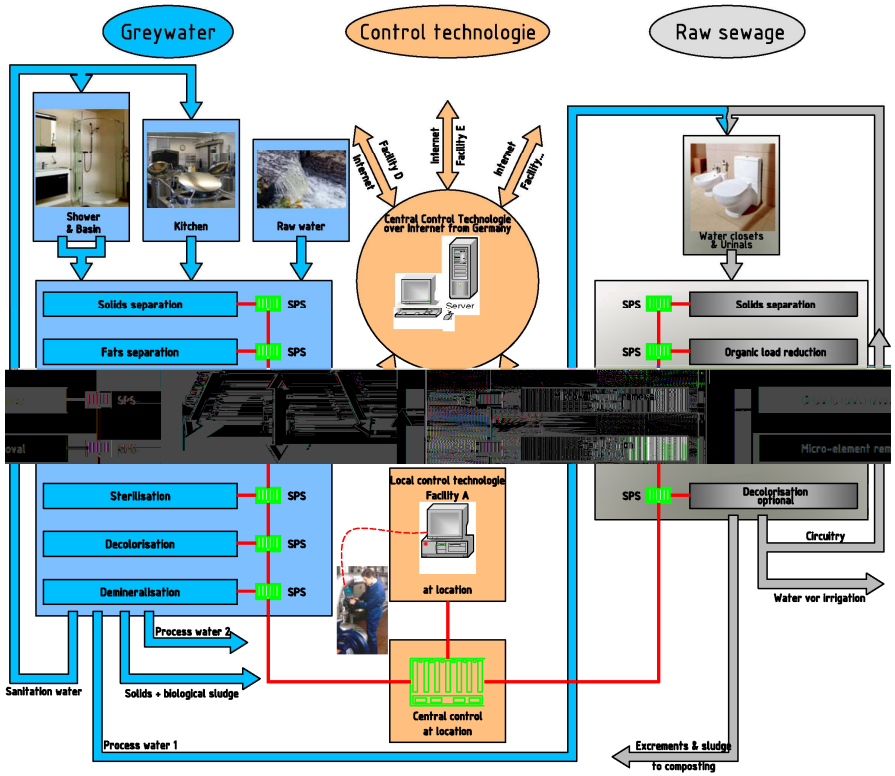
  … independence of centralized infrastructure systems for water supply, wastewater and waste disposal

  … independence from weather influences

Basic Idea

Remote monitoring through experts

Separation of wastewater flows



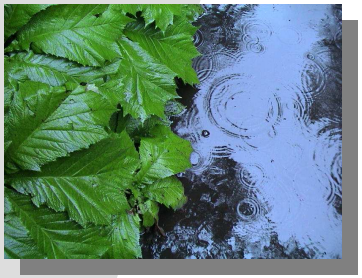
Modular construction

Sanitary equipment

Resource

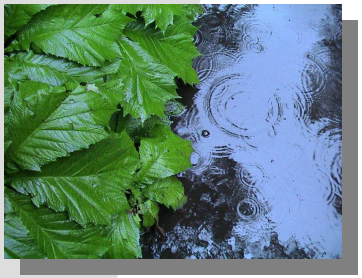
Treatment concerning requirements

Procedure



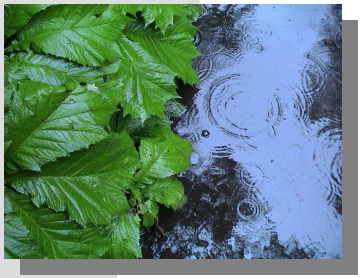
- **fundamental phase**
  - characterization of grey- and blackwater
  - pretest biological treatment
  - test plant using MBR-technology (5 i.e.)
    → generating of reference values for the pilot plant
- **technical scale phase**
- **pilot scale phase**

Procedure



- **fundamental phase**
- **technical scale phase**
  - integration of further plant components for water purification in a technical scale plant (20 i.e.)
  - development of operation strategies to achieve optimum water qualities
    - → greywater: drinking water quality
    - → blackwater: reuse for toilet flushing or irrigation
  - operation phase: 01|2007 - 10|2007
- **pilot scale phase**

Procedure



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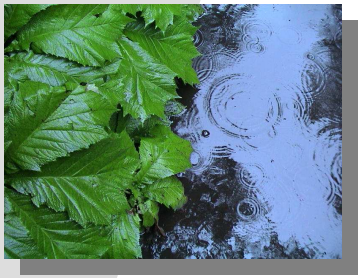
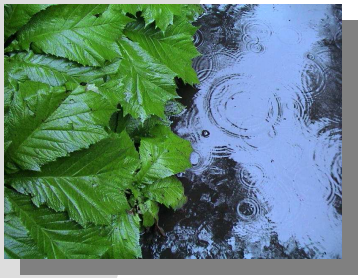
- **technical scale phase**
  - integration of further plant components for water purification in a technical scale plant (20 i.e.)
  - development of operation strategies to achieve optimum water qualities
  - operation phase: 01|2007 - 10|2007
  - development of sanitary products and intelligent diagnosis system
- **pilot scale phase**

Procedure



- **fundamental phase**
- **technical scale phase**
- **pilot scale phase**
  - integration of Komplett-System in an office building as a demonstration plant (150 - 200 i.e.)
  - close of water cycles
    - → greywater: showers, washing machines
    - → blackwater: toilet flushing
  - coupled system of sanitary equipment, treatment and visualization

Procedure



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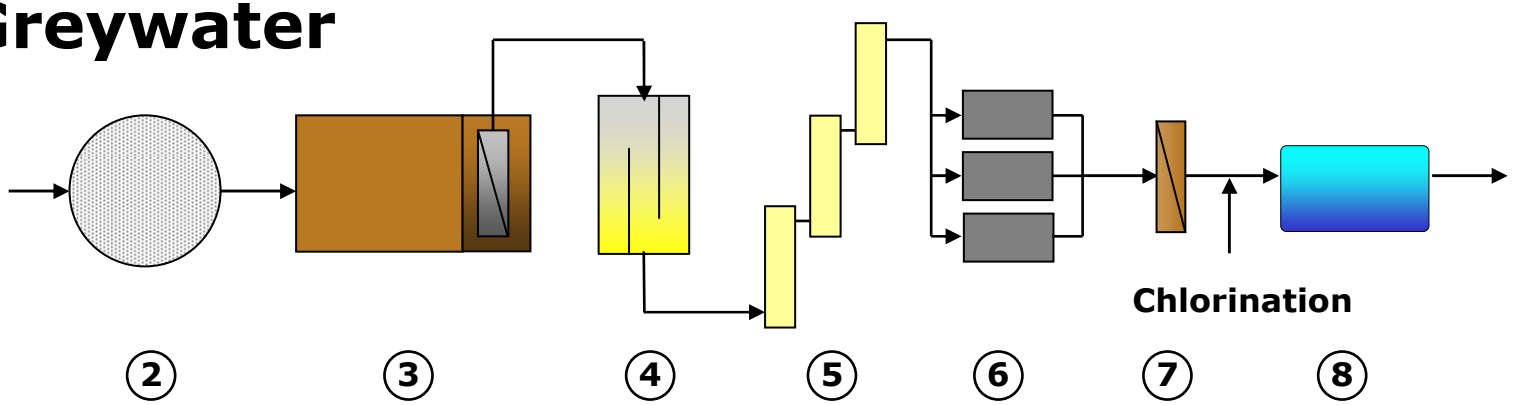
- **technical scale phase**
- **pilot scale phase**
  - integration of Komplett-System in an office building as a demonstration plant (150 - 200 i.e.)
  - close of water cycles close of water cycles
  - coupled system of sanitary equipment, treatment and visualization
  - acceptance of users
  - enrichment of certain pollutants

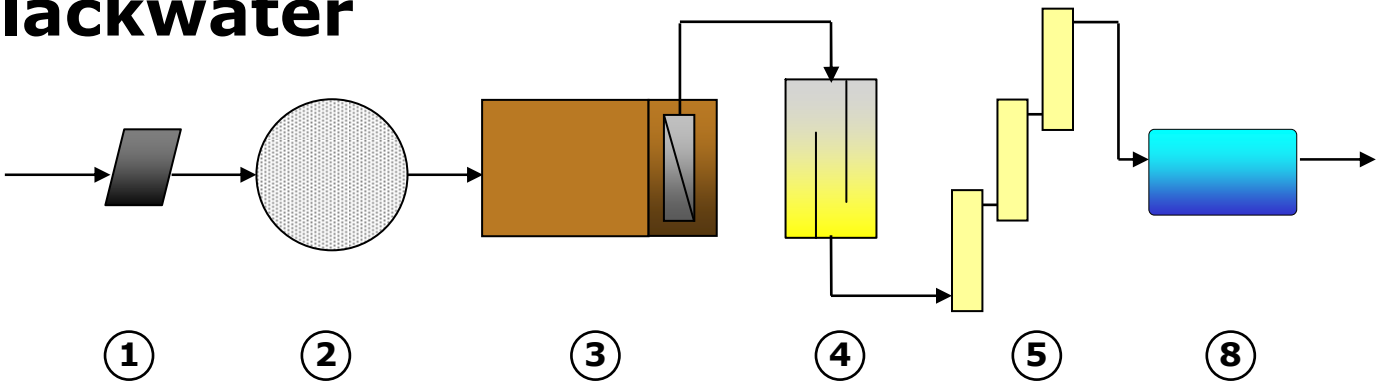
The Pilot Plants

1 Rotation screen
2 Storage tank
3 Membrane-Bio-Reactor
4 Ozonation
5 UV-Disinfection
6 Activated carbon filt.
7 Ultrafiltration
8 Storage tank

Greywater



Blackwater



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Performance Greywater Plant

summary of greywater quality and removal efficiency (Apr – Oct 2007)

Greywater								
Parameter		**Unit**	**ST**	**MBR**	**OZ**	**UV**	**ACF**	**UF**
COD	Average	mg/L	600	47.5	20.8	24.6	< 5	< 5
	removal efficiency	%	-	92	97	96	99	99
TN	Average	mg/L	12.9	1.4	1.4	1.4	1.2	1.2
	removal efficiency	%	-	88	88	90	91	91
TP	Average	mg/L	6.9	2.0	2.0	1.9	-	1.8
	removal efficiency	%	-	68	68	68	-	72
E. coli	Median	CFU/100mL	1.20E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	removal efficiency	%	-	100	100	100	100	100
Streptoccocus	Median	CFU/100mL	4.81E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	removal efficiency	%	-	100	100	100	100	100

ST … Storage tank; MBR … Membrane-Bio-Reactor; OZ … Ozonation; UV … UV-Disinfection; ACF … Activated Carbon Filtration; UF … Ultrafiltration (including ClO_2)

Performance Greywater Plant

comparison of effluent to requirements for drinking water (selection)

		Guideline		KOMPLETT
Parameter	**Unit**	**EU 1998**	**TVO 2001**	**Apr - Oct 2007**
Conductivity	**µS/cm**	**2,500**		**562**
pH-value	**pH-value**	**6.5 -9.5**		**7.7**
Boron	**mg/L**	**1.0**		**< 0.03**
Chromium, total	**mg/L**	**0.05**		**< 0.005**
Cyanide, total	**mg/L**	**0.05**		**< 0.005**
Fluoride	**mg/L**	**1.5**		**< 0.1**
Nitrate	**mg/L**	**50**		**5.6**
Nitrite	**mg/L**	**0.5**		**< 0.02**
Mercury	**mg/L**	**0.001**		**< 0.0005**
Selenium	**mg/L**	**0.01**		**< 0.001**
Arsenic	**mg/L**	**0.01**		**< 0.002**
Lead	**mg/L**	**0.01**		**< 0.005**
Cadmium	**mg/L**	**0.005**		**< 0.0005**
Copper	**mg/L**	**2.0**		**< 0.01**
Nickel	**mg/L**	**0.02**		**< 0.005**
Postatium permanganate consumption	**mg/L O_2**	**5.0**		**< 0.04**
E.coli	**CFU/100mL**	**0**		**0**
Streptoccocus	**CFU/100mL**	**0**		**0**
HPC 20	**CFU/mL**	**20**		**0**
HPC 36	**CFU/mL**	**100**		**30**

TVO (2001) … German Technical and Scientific Association for Gas and Water, German drinking water directive

EU (1998) … European Union, Directive 98/83/EC: Council Directive of 3 November 1998 on the quality of water intended for human consumption

Performance Blackwater

summary of blackwater quality and removal efficiency (Apr – Oct 2007)

Blackwater						
Parameter		**Unit**	**ST**	**MBR**	**OZ**	**UV**
COD	Average	mg/L	720	136.4	40,0	24,5
	removal efficiency	%	-	82	94	97
TN	Average	mg/L	279,0	133,5	150,2	145,9
	removal efficiency	%	-	52	48	50
TP	Average	mg/L	29,2	29,2	30,5	30,5
	removal efficiency	%	-	0	-7	-7
E. coli	Median	CFU/100mL	2,20E+06	0,00E+00	0,00E+00	0,00E+00
	removal efficiency	%	-	100	100	100
Streptoccocus	Median	CFU/100mL	4,14E+05	0,00E+00	0,00E+00	0,00E+00
	removal efficiency	%	-	100	100	100

ST … Storage tank; MBR … Membrane-Bio-Reactor; OZ … Ozonation; UV … UV-Disinfection

Performance Blackwater

comparison of effluent to requirements for toilet flushing water (selection)

		Guideline		KOMPLETT
Parameter	**Unit**	**U.S.EPA 2004**	**FBR 2004**	**Apr - Oct 2007**
Temperature	**°C**	**-**	**-**	**33.7**
Conductivity	**mS/cm**	**-**	**-**	**1.7**
pH-value	**pH-value**	**6 - 9**	**-**	**4.1**
Dissolved Oxygen	**%**	**-**	**> 50**	**n.d.**
Biological Oxidation Demand (BOD_5)	**mg/L**	**10**	**5.0[1)]**	**3.7[2)]**
Total suspended solids	**mg/L**	**5.0**	**-**	**n.d.**
E.coli	**CFU/100mL**	**0**	**1,000**	**0**
Ps. aeruginosa	**CFU/100mL**	**-**	**100**	**2**

U.S. EPA (2004) … U.S. Environmental Protection Agency, Guidelines for Water Reuse USEPA/625/R-04/108
FBR (2005) … German association of professionals for service and rainwater utilization, Guideline H 201

Summary

- **process scheme produces high effluent qualities for separated grey- and blackwater and provides a safe and alternative source of water supply**
- **greywater effluent quality meets highest requirements for utilization, e.g. drinking water standards of EU**
- **blackwater effluent quality corresponds to international reuse standards for toilet flushing**
  - nitrogen removal is limited in the biological process
  - blackwater contains a high fraction of inert COD

Outlook

- **integration of the Komplett-System as a Demonstration plant in Oberhausen**
  - enrichment of micro-pollutants and reverse accumulation
  - users acceptance
  - …
- **start of demonstration phase: 01|2007**

thank you for your attention!

www.KOMPLETT-projekt.de

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