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Nature-based SMART solution for water recovery of surface water polluted by black and greywater – A feasibility study at the Water-Hub

Future Water Lunch Seminar 28/11/2023

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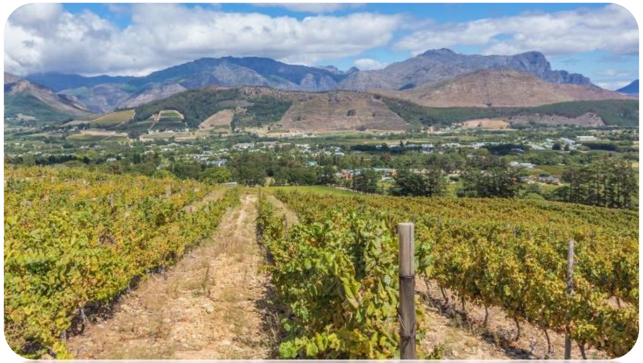


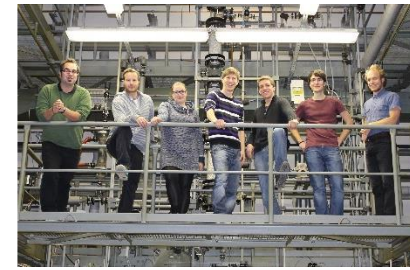
Bavarian State Ministry of the
Environment and Consumer Protection

Background

Karlsruhe Institute of Technology
FRIEDRICH-SCHILLER-UNIVERSITÄT JENA
Scottish Water
Trusted to serve Scotland
UNIVERSITY OF KWAZULU-NATAL
UNISA university of south africa
Khanyisa PROJECTS

Germany → UK → South Africa → Germany

- MSc Environmental Chemistry



- PhD in Water Science
PostDoc on microplastic removal

- PostDoc on water treatment and reuse

- Research associate on nature-based solution at the Water-Hub

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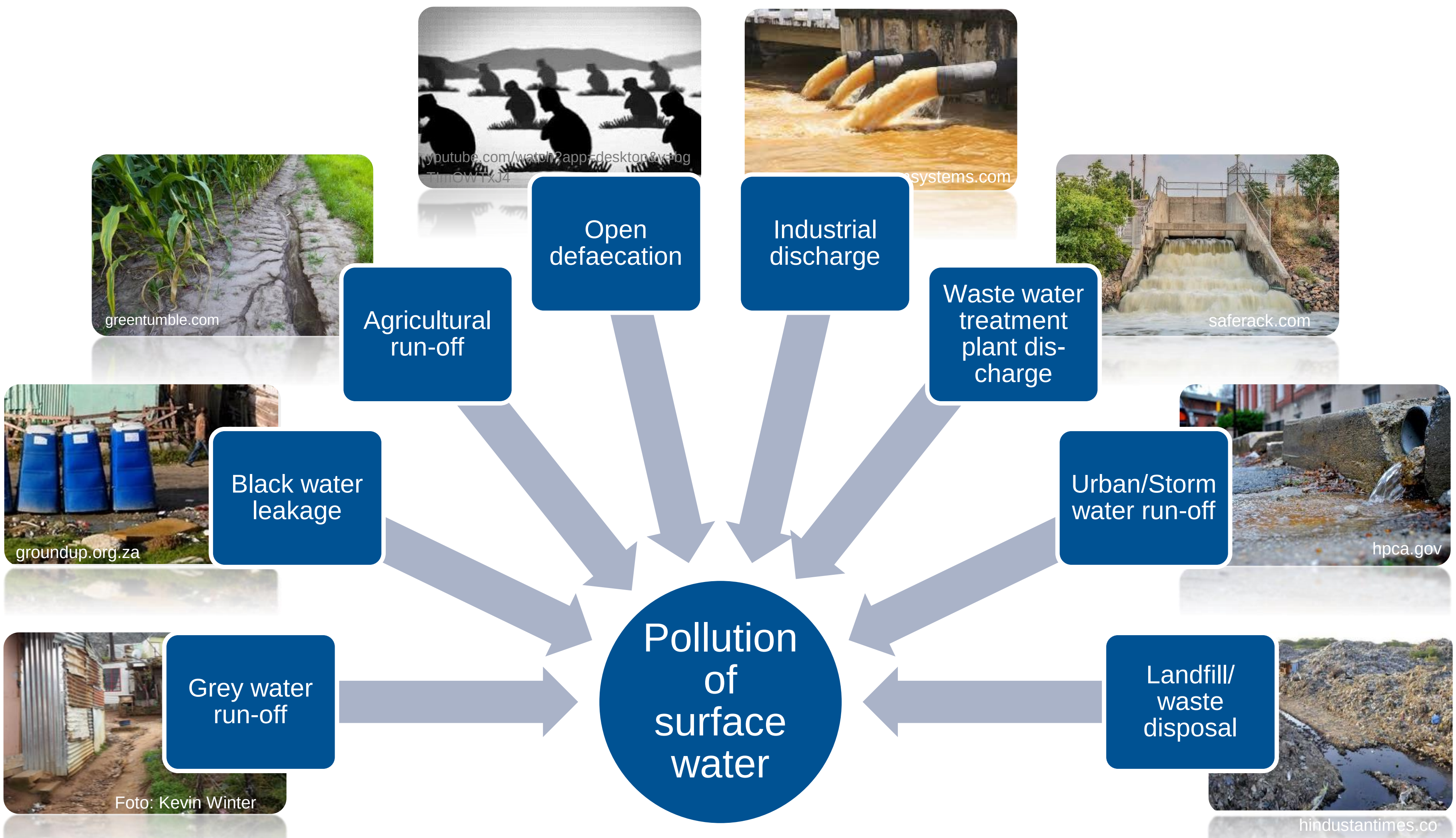
Contamination of surface water



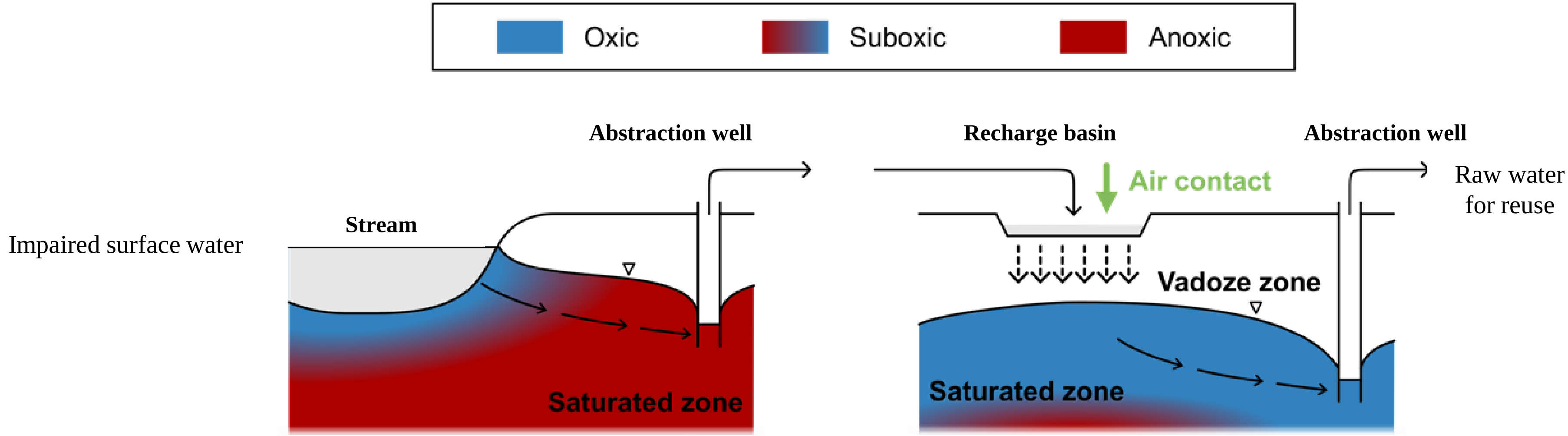
Treating contamintated surface water with SMART

SMART
=
Sequential Managed Aquifer Recharge Technology

- Natural attenuation processes for chemical and microbial contaminants during soil passage
- Inactivation of pathogens and improved removalof many trace organic chemicals
- Small footprint
- Low energy system
- Low maintenance

Principle of Sequential Groundwater Recharge Technology

Sequence of controlled redox conditions in the subsurface with an optional intermittend electron acceptor delivery



SMART – *Sequential Managed Aquifer Recharge Technology*

Regnery et al. (2016), Chemosphere 154, 8-16

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Comparision of conventional groundwater recharge to SMART (Field testing Berlin)

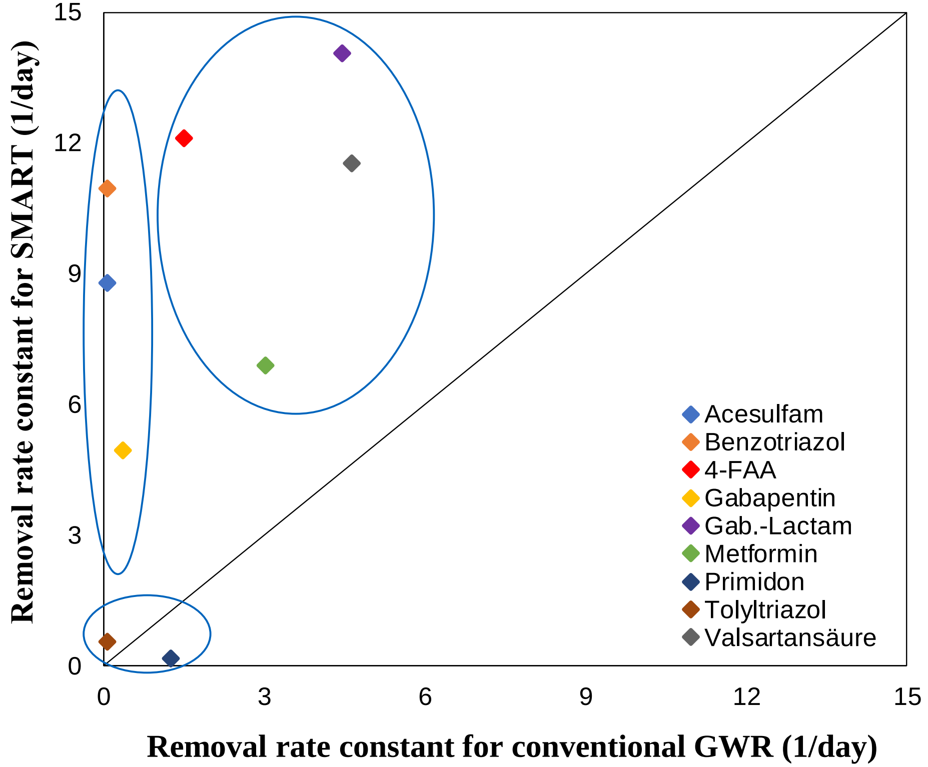
Berliner Wasserbetriebe

SMART operating conditions:

- Stable oxic redox conditions
  (oxic, DO > 2 mg/L)
- Carbon-limiting conditions
- Retention time: 2 hrs. – 11 days

Conventional GWR operating conditions:

- Instable redox conditions
  (oxic-suboxic, DO: 0-2 mg/L)
- Elevated BDOC concentrations
- Retention time: 3 hrs. – 25 days



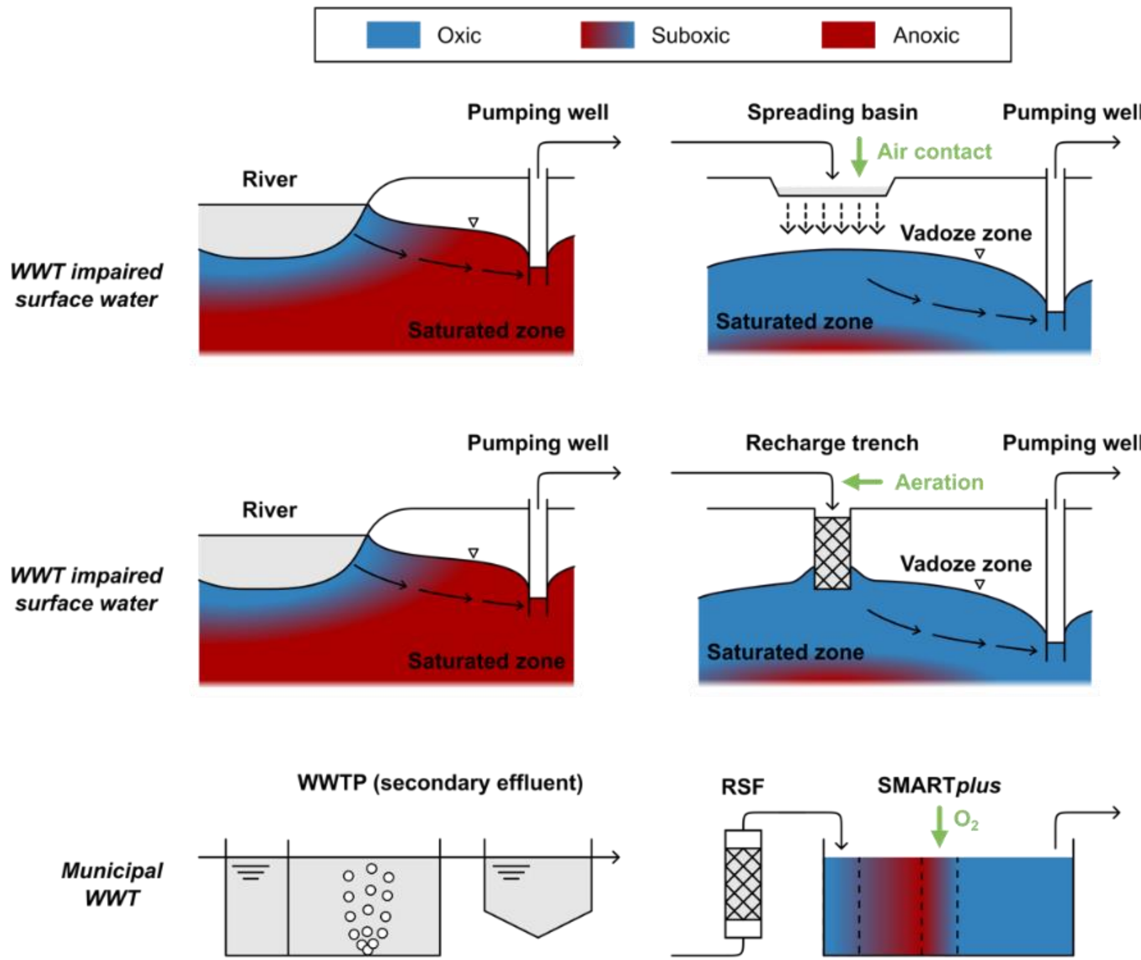
Hellauer et al. 2018, J. Hydrology 563, 1161

From SMART 1.0 to SMART 2.0 and SMART*plus*

Option 1
SMART 1.0

Option 2
SMART 2.0

Option 3
SMART*plus*



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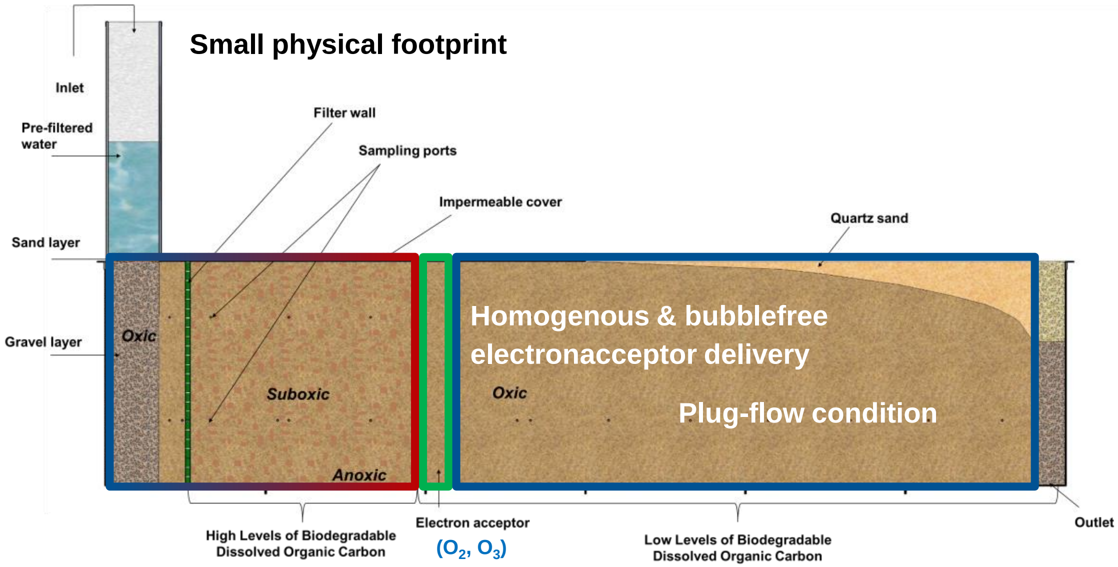
Transitioning from SMART 1.0 to SMART*plus*



- Oligotrophic & oxic conditions
- Reduced physical footprint
- Controlled hydraulic plug-flow conditions
- *in situ* electron acceptor delivery

Karakurt et al. 2020, STOTEN **722**, 137890

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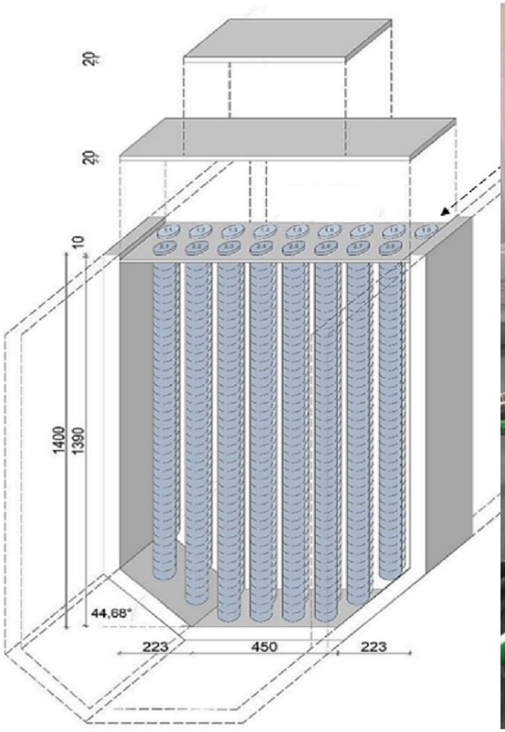
SMART*plus*

Pilot-scale experiments under controlled conditions

- Silicon membranes (PDMS)
- Oxygen partial pressure (0,8 – 1,0 bar)
- Oxid conditions after O_2-delivery



S. Karakurt et al., 2020

A. Schmuck, 2020

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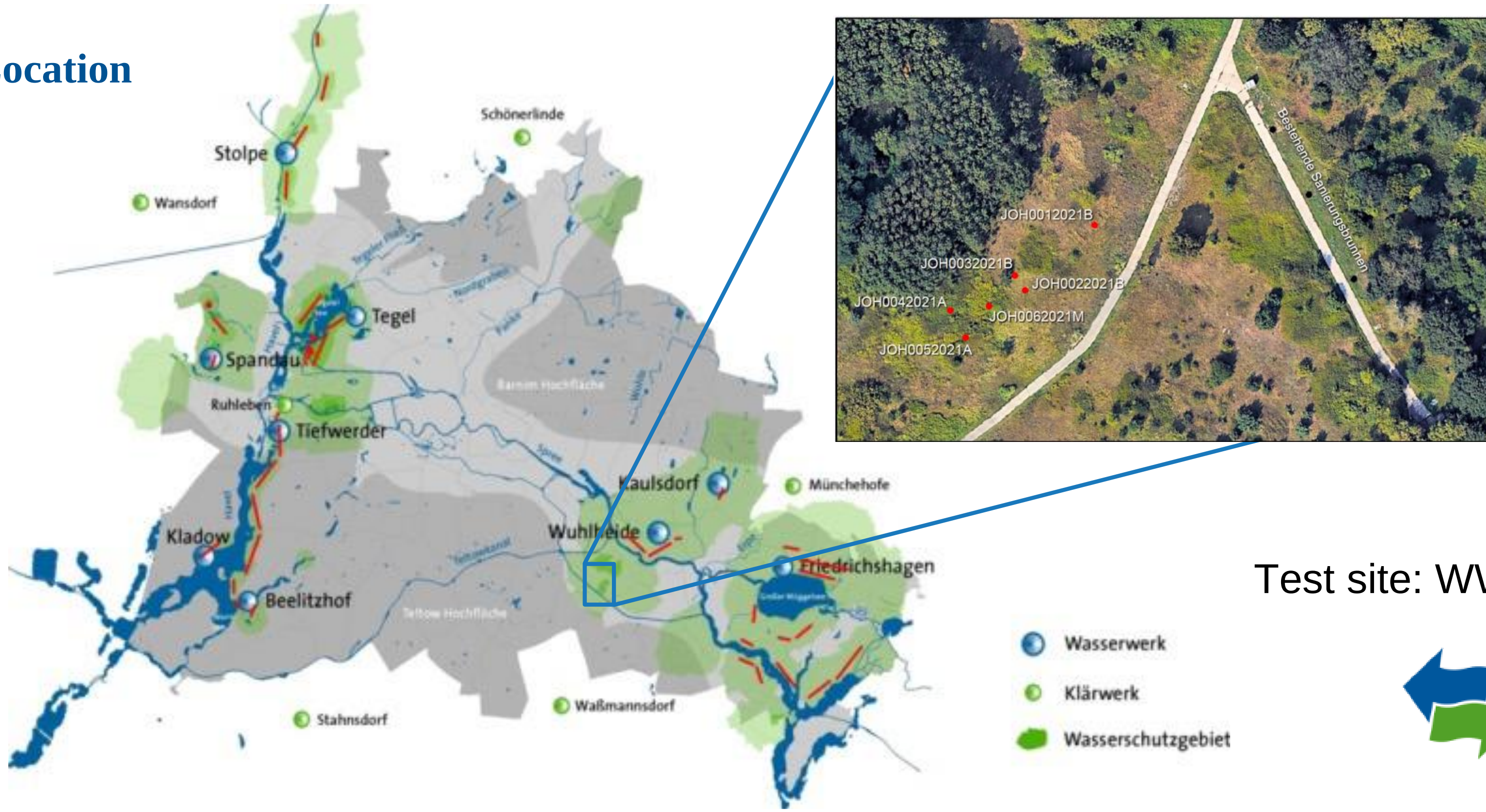
Potable Reuse for Drinking Water Augmentation: City of Berlin: SMART 2.0

Location



Test site: WW Johannisthal

Berliner Wasserbetriebe

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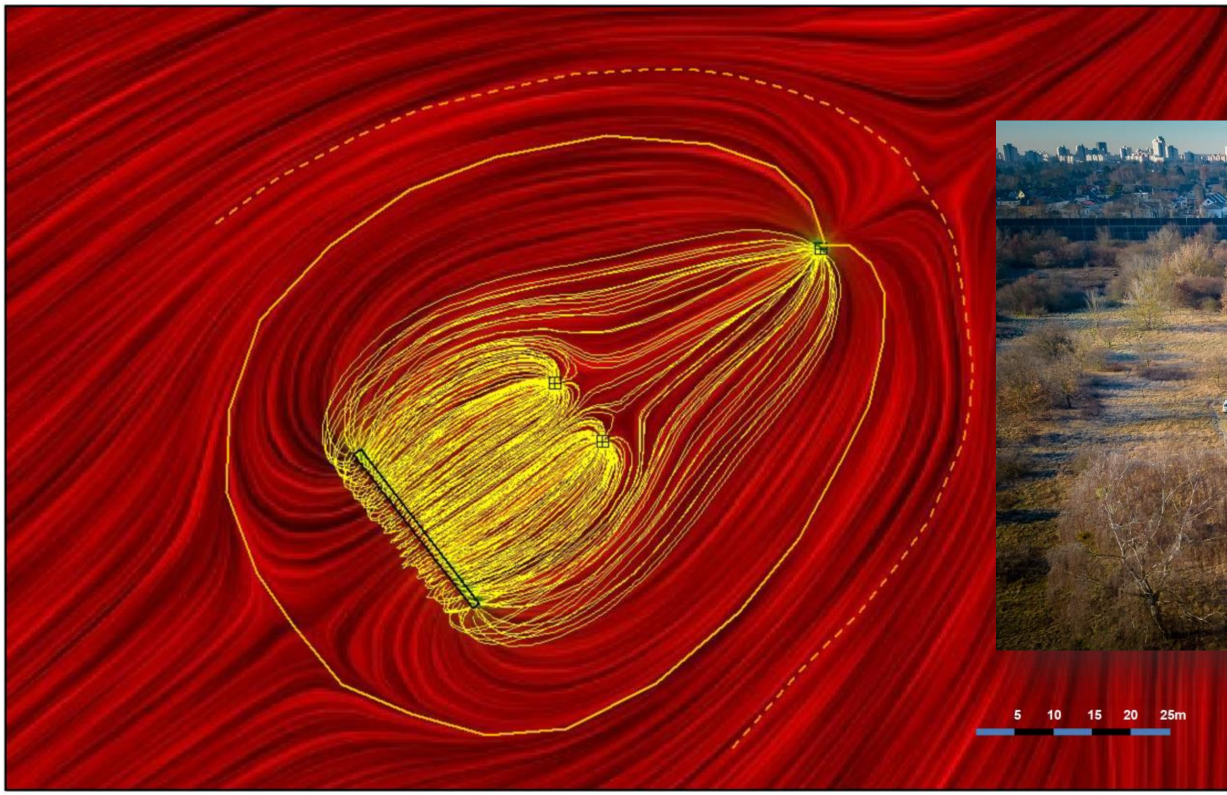
SMART 2.0: Ground water model (BGS)

Hydraulic regime



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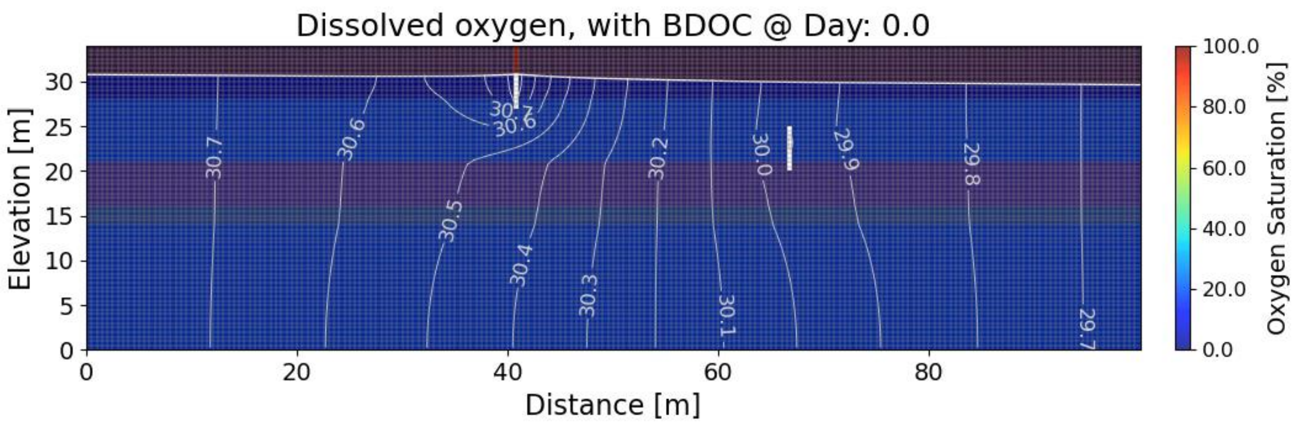
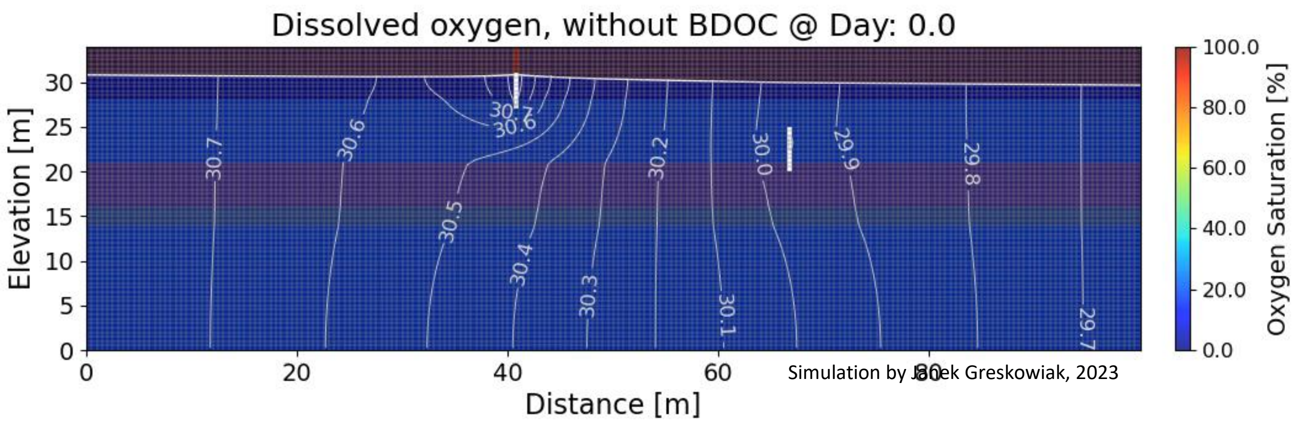
Preliminary: 2D Vertikalmodel

Reactive contaminant transport

Oxic Anoxic





Riverbank filtration conditions (w/ BDOC)

k_{Sed} = 0.56 mg/L/d
k_{BDOC} = 5.6 mg/L/d

SMART
(no BDOC)

k_{Sed} = 0.56 mg/L/d

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Implementation of the SMART system at the Water Hub

Photo: Kevin Winter

Photo: Kevin Winter

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Treatment cells (biofilters) for treatment of river water

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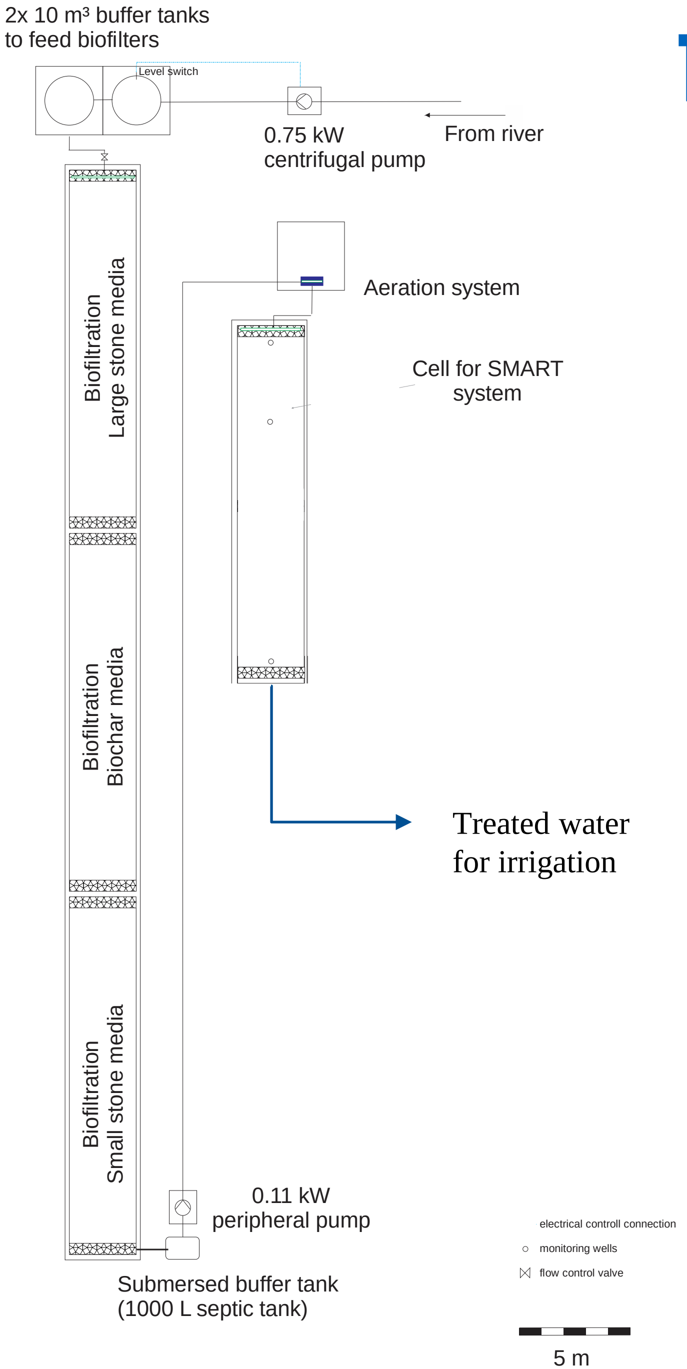
Biofilters for SMART

Biofilters as initial treatment step

- Treatment train of 3 biofiltration media (coarse gravel, biochar, small stones)
- Plug-flow conditions shown in pilot study
- Volume of 1.227 m^3/h
- Residence time per filter 11.5 h

SMART system

- Aeration through cascade
- Infiltration trench (fine gravel)
- Filtration media: Filtration sand (0.5 mm – 1.4 mm)
- Volume of 1 m^3/h
- Residence time 13.6 h



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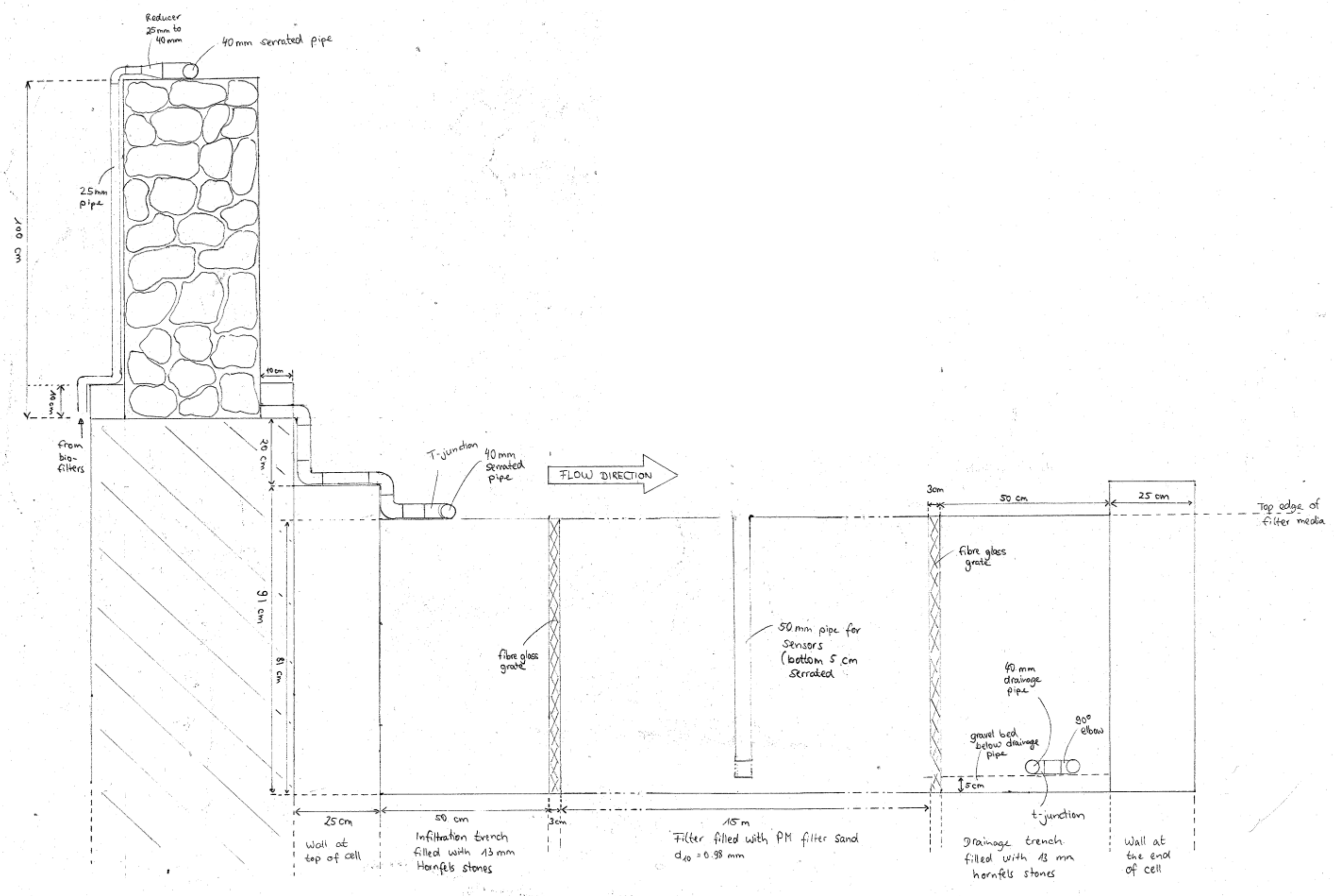
Aeration system



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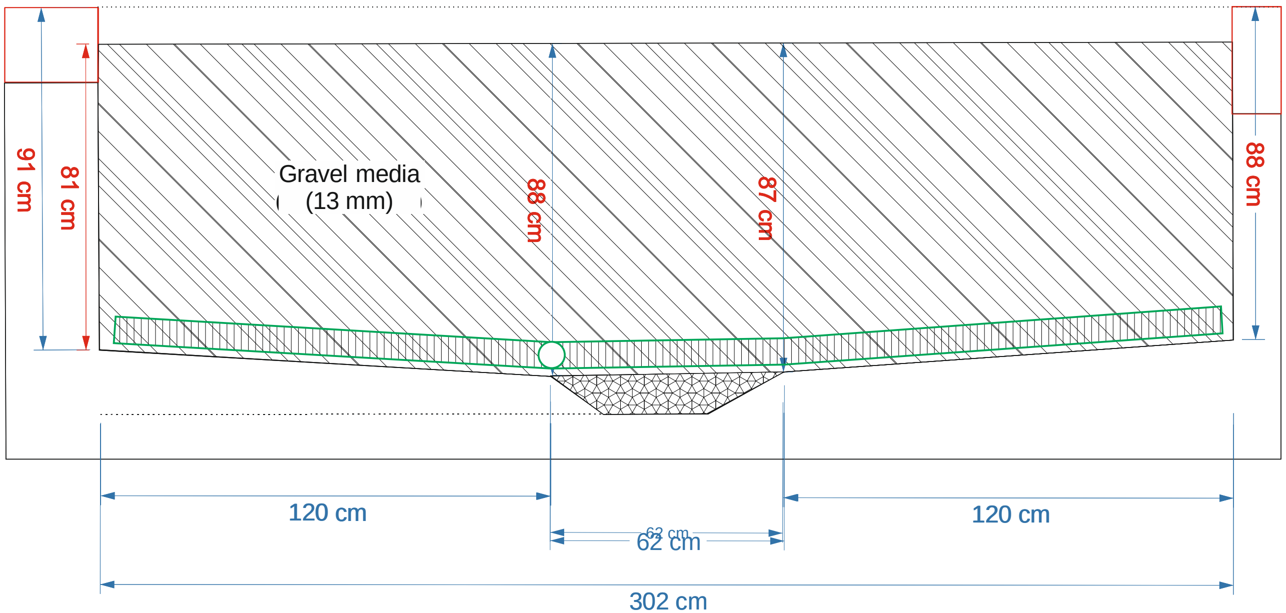
Cells for SMART system

Cross-section of treatment cell

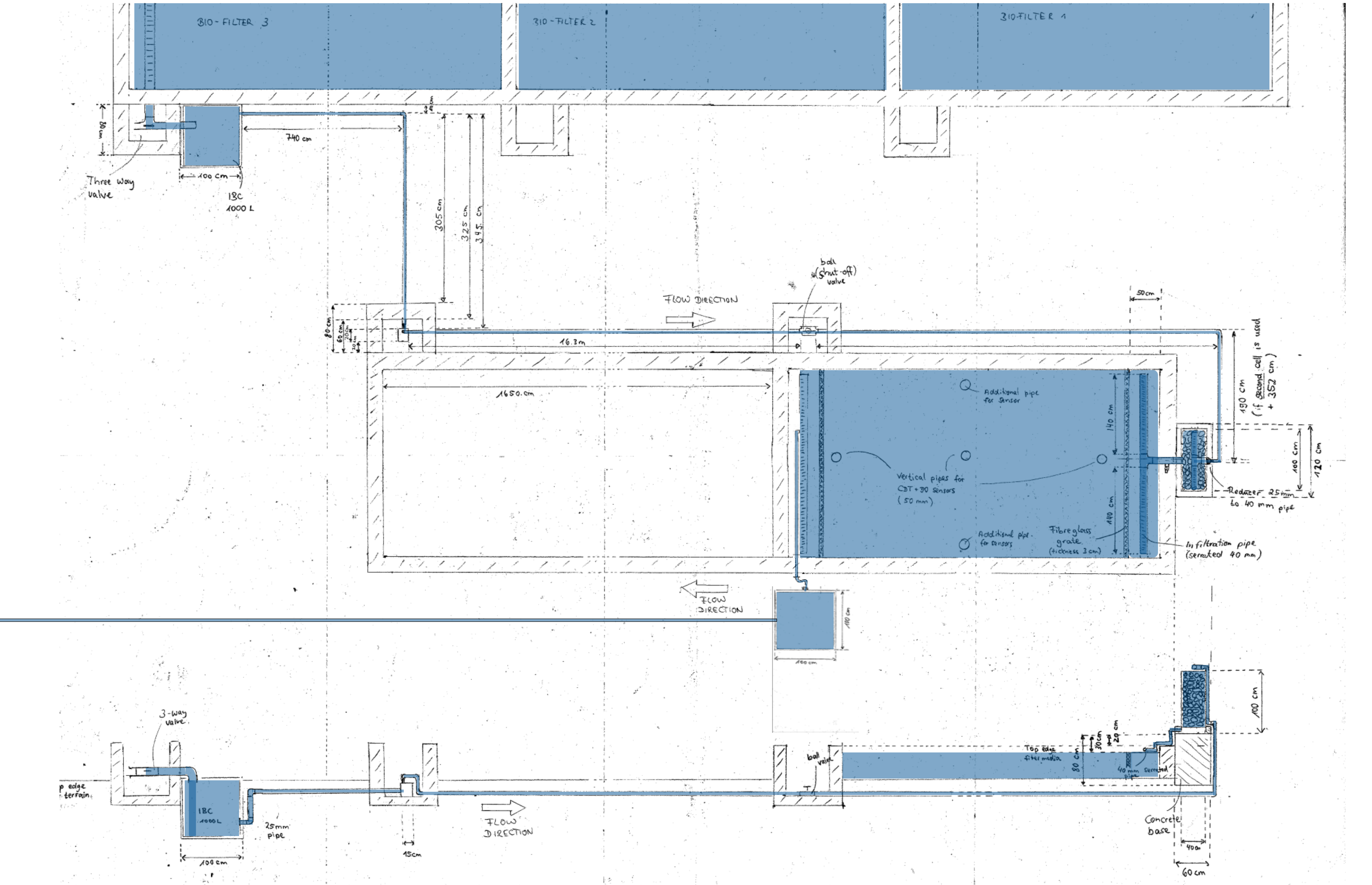


Volume: ca 41 m³ (water volume ca 18 m³ at 0.44 porosity)

Filtration area: 2.6 m²

Conductivity: $7.26 \cdot 10^{-3}$ m/s (sand, d_{10} = 0.98 mm)

Flow: max 0.95 m³/h


BIO - FILTER 3
BIO - FILTER 2
BIO-FILTER 1
80 cm
740 cm
100 cm
Three way valve
IBC 1000 L
305 cm
325 cm
345 cm
ball (shut-off) valve
FLOW DIRECTION
16.3 m
50 cm
1650 cm
Additional pipe for sensor
Vertical pipes for CDT + 30 sensors (50 mm)
140 cm
190 cm (if second cell is used + 352 cm)
100 cm
120 cm
Reducer 25 mm to 40 mm pipe
Additional pipe for sensors
Fibreglass grate (thickness 3 cm)
Infiltration pipe (serrated 40 mm)
FLOW DIRECTION
100 cm
3-way valve
edge terrain
IBC 1000 L
25 mm pipe
100 cm
15 cm
FLOW DIRECTION
ball valve
Top edge filter media
30 cm
20 cm
80 cm
40 mm pipe
Serrated
Concrete base
40 cm
60 cm

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Use of treated water for irrigation

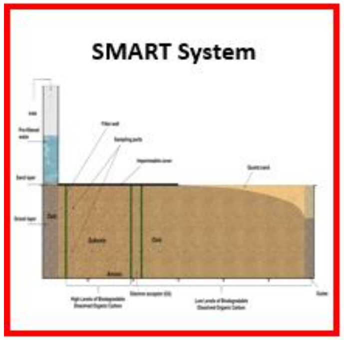
Simple, low-tech and low-energy nature-based solutions able to treat highly polluted water to quality that is safe for irrigation of food crops

Comparison of crop irrigated by water of different quality

Further research on uptake of trace organics in plants

Creation of market gardens

Objectives



Planning and installation of SMART system

Upgrading of solar system

Socio-economic survey

Survey for biogas potential

Questions?

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Technische Universität München

Western Cape Government
Environmental Affairs and Development Planning

funded by
Bavarian State Ministry of the Environment and Consumer Protection