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Promoting Water Recycling in the Baltic Sea Region

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The WaterMan project
Feasibility study on reuse of water from large-scale WWTPs

Pia Schumann

Berlin Centre of Competence for Water

Content

- The challenge
- The opportunity
- **(Industrial) water reuse at WWTP Ruhleben**
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  - Concept & approach
  - Water quantity
  - Water quality
  - Pipeline costs
- **(Agricultural) water reuse at WWTP Stahnsdorf**
  - Context
  - Stakeholders
  - Technical solution
- Quantitative microbial risk assessment
- Key findings, transferability & final reflections

The challenge

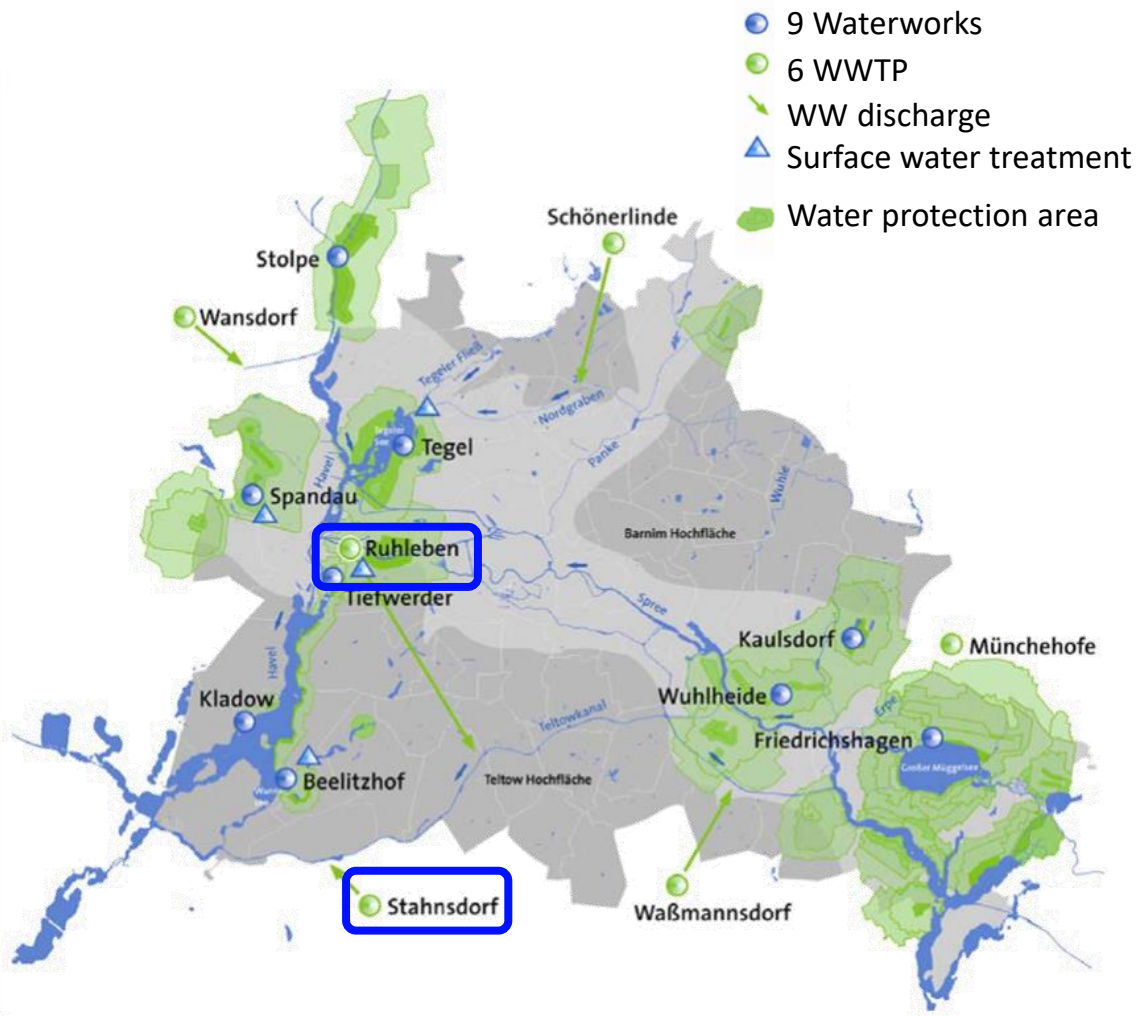
Future challenges of water supply in the Berlin Brandenburg Metropolitan Region

- Population Growth: Rising demand due to increasing population
- Climate Change: Reduced water availability (e.g., the dry five-year period 2018–2022)
- Decline in Spree River Flow: End of lignite mining and related mine drainage inflows
- Decline in Havel River Flow: Lower precipitation levels

The opportunity

1. (Industrial) water reuse at WWTP Ruhleben
   - There is a large wastewater treatment plant (WWTP) in the city, in close proximity of a commercial zone
   - More detailed assessment of industrial reuse potential, building upon the study by Heinrich and Wilmes (2022)

2. (Agricultural) water reuse at WWTP Stahnsdorf
   - High interest of Berlin water utility and the local mayor in water reuse opportunities



Source: Berlin water utilities (BWB)

Heinrich & Wilmes: Potenziale der Wasserwiederverwendung am urbanen Klärwerk Ruhleben (2022)

WWTP Ruhleben

The context – WWTP Ruhleben

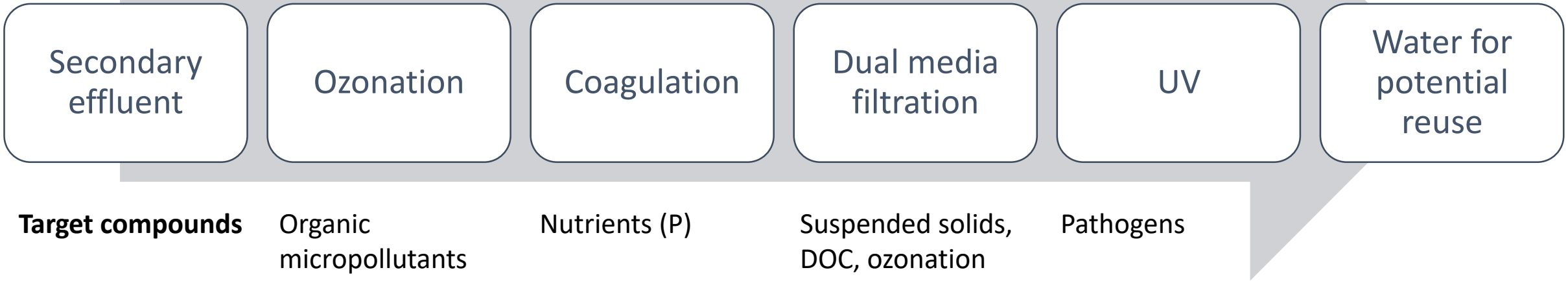
- Aim to assess the potential of reuse of municipal wastewater at WWTP Ruhleben
  - Focus on industrial & commercial reuse
  - Urban irrigation may be included as well
- large urban WWTP near industrial/commercial zone
- Discharge of treated WW:
  - Winter period: Spree river
  - Summer period: Teltowkanal (16 km distance)
- Current capacity of 247,500 m³/day
- Planned extentions:
  - Coagulation filtration for nutrient removal + full-stream UV disinfection (until 2027)
  - Advanced treatment for micropollutant removal (e.g. activated carbon, ozonation)


Source: Berlin water utilities (BWB)

The context - WWTP Ruhleben Upgrade

Secondary effluent → Ozonation → Coagulation → Dual media filtration → UV → Water for potential reuse

The context - WWTP Ruhleben Upgrade



Target compounds	Organic micropollutants	Nutrients (P)	Suspended solids, DOC, ozonation transformation products	Pathogens	

The context - WWTP Ruhleben Upgrade

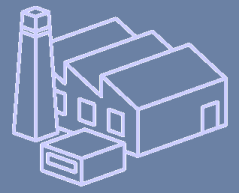
Secondary effluent	Ozonation	Coagulation	Dual media filtration	UV	Water for potential reuse
Target compounds	Organic micropollutants	Nutrients (P)	Suspended solids, DOC, ozonation transformation products	Pathogens	
Implemented by	2045 at the latest (UWWTD)	2027 (planned)	2027 (planned)	2027 (planned)	

The context - WWTP Ruhleben Upgrade

Secondary effluent	Ozonation	Coagulation	Dual media filtration	UV	Water for potential reuse
Target compounds	Organic micropollutants	Nutrients (P)	Suspended solids, DOC, ozonation transformation products	Pathogens	
Implemented by	2045 at the latest (UWWTD)	2027 (planned)	2027 (planned)	2027 (planned)	
Treatment target	UWWTD 80% removal of indicator OMP		Water Framework Directive: TSS < 1 mg/L TP < 0.1 mg/L	Bathing water quality („good“ status)	

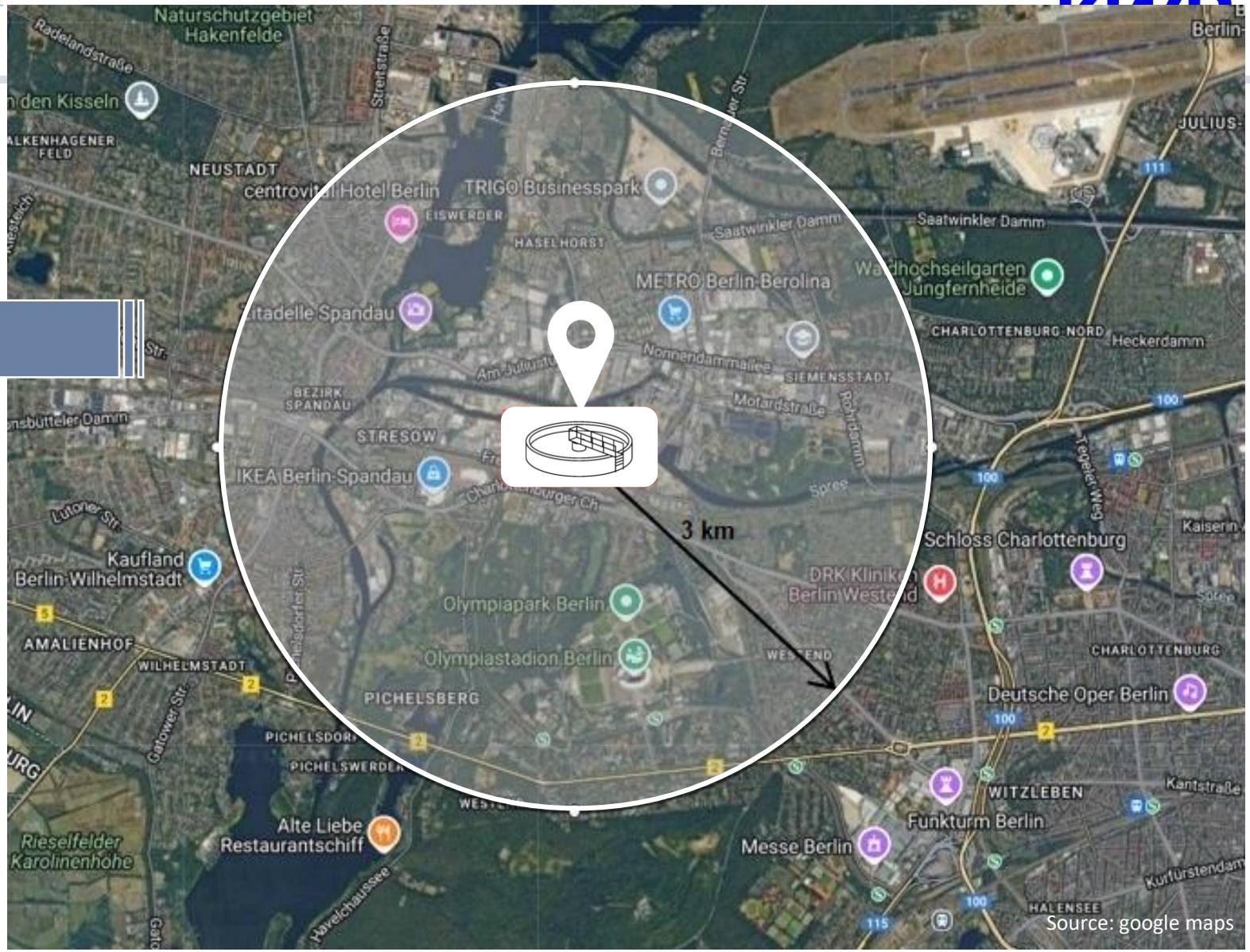
Concept & approach

189 industries / businesses



- water consumption
- non-food

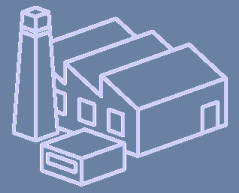
25 priority industries / businesses



Source: google maps

Concept & approach – WWTP Ruhleben

189 industries / businesses



- water consumption
- non-food

25 priority industries / businesses

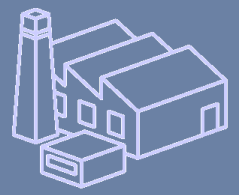
@

- Received responses from 2 businesses
- Discussed potential areas for cooperation
- No concrete opportunities identified

Name of Industry	Category	Distance from Ruhleben in km
Aks Dasis Dommermuth GmbH & Co KG	Cooling and air conditioning	1.53
Aladdin Auto Werkstatt	Car repair shop	0.78
ATU Berlin - Spandau	Car repair shop	0.74
Auto-Eid Autoverwertung	Car repair shop	0.47
Automobile D.A.H West	Car repair shop	1.36
Autoservice Müller	Car repair shop	0.35
BERGER BETON SE	Ready mix concrete supplier	0.46
Berlin Recycling GmbH Recycling company	Waste management service	0.33
BeST Berliner Sensortechnik GmbH	Electronic manufacturer	3.06
BMW spez. DREIMW Fahrzeugtechnik GmbH	Car repair shop	0.63
BSR Biogasanlage West	Waste management service	0.68
BSR Müllheizkraftwerk Ruhleben	Waste management service	1.12
BTB - Werkstatt für Mobilkrane und Nutzfahrzeuge	Truck repair shop	1.90
Clean Car	Car wash	0.56
Feigel umwelt-service gmbh	Environmental services or waste management	0.37
Gerken GmbH - Arbeitsbühnenvermietung Niederlassung Berlin	Construction machine rental service	1.13
Graf Baustoffe | Berlin - Brandenburg	Building material store	0.85
Halter Spreng- und Umwelttechnik	Demolition contractor	0.43
Hasan Solmaz - Autoservice	Car repair shop	0.85
KEL CAR Karsli UG	Car repair shop	0.23
MAN Truck & Bus Center Berlin	Truck repair shop	0.73
MAN Truck & Bus Germany GmbH	Truck repair shop	1.45
Mr. Wash Berlin Spandau	Car wash	0.69
RUWE Gruppe | Betriebshof Nord-West	service provider for street cleaning and green areas	0.46
The GARAGE auto repair shop	Car repair shop and maintenance service	1.45
Vattenfall Wärme Berlin AG, Heizkraftwerk Reuter	Power station	0.99

Concept & approach – WWTP Ruhleben

189 industries / businesses



- water consumption
- non-food

25 priority industries / businesses

- Most relevant

2 priority categories

Name of Industry	Category	Distance from Ruhleben in km
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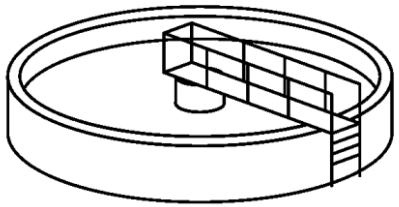
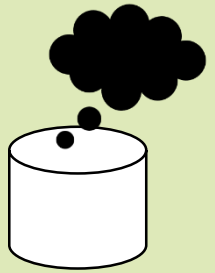
Water quantity – Car wash and cooling



247,500 m³/day treated wastewater

4 – 44 m³/day[1]



3,500 – 18,000 m³/day[2]

Max. 7% of the daily wastewater volume of the WWTP Ruhleben

[1]Löffler et al., 2024 doi 10.2166/wst.2024.300; personal communication, [2]based on average yearly energy production and water consumption according to Pan et al., 2018: https://doi.org/10.1016/j.wen.2018.04.002

Water quality

Requirements for car wash and cooling towers according to European guidelines

Parameter	Unit	Car wash[1]	Cooling tower[2]
Aluminium	µg/L		< 500
Calcium	mg/L		>20 / <500
Carbon hardness	°dH		< 4 /< 20
Chloride	mg/L		< 50 / < 250
Conductivity	µS/cm		50 - < 3000
Copper	µg/L		< 500
E. Coli	CFU/100 mL; MPN/100mL	200	Absence
Intestinal nematodes	eggs/10L	<1	<1
Iron	mg/L		< 0.1 / < 0.5
Legionella	CFU/L		<100
Magnesium	mg/L		<100
pH			7 - 9
Sulphate	mg/L		< 50 / < 600
TDS	g/L		<1.8
Total Hardness	°dH		<8
TSS	mg/L	<20	< 5
Turbidity	NTU	<10	< 1

[1]Royal Decree (1620/2007) (2007) Spanish Regulations for Water Reuse – Royal Decree 1620/2007 of 7 December. Madrid: Spanish Association for Sustainable Water Reuse ASERSA, Universitat Politècnica de Catalunya, UPC and Consorci de la Costa Brava, CCB.

[2]Royal Decree (1620/2007) (2007) Spanish Regulations for Water Reuse – Royal Decree 1620/2007 of 7 December. Madrid: Spanish Association for Sustainable Water Reuse ASERSA, Universitat Politècnica de Catalunya, UPC and Consorci de la Costa Brava, CCB.

VDI 2047 Blatt 2 (2015) Rückkühlwerke – Sicherstellung des hygienegerechten Betriebs von Verdunstungskühlanlagen, Rule Number: VDI 2047 Blatt 2 2015 Düsseldorf: Verein Deutscher Ingenieure e.V.

VDI 3803 Blatt 1 (2019) Raumlufttechnik – Bauliche und technische Anforderungen Zentrale raumlufttechnische Anlagen (VDILüftungsregeln). Rule Number: VDI 3803 Blatt 1 2019 Düsseldorf: Verein Deutscher Ingenieure e.V.

Niewersch, C., Arias, A., Sukopova, M. & Gilron, J. (2016) Deliverable 1.3 - Report on Innovative Membrane Technologies and Schemes for Water Reuse. Tarragona, Spain: Dow Chemical Ibérica.

Water quality

Requirements for car wash and cooling towers according to European guidelines

Comparison to secondary effluent of WWTP Ruhleben

Parameter	Unit	Car wash[1]	Cooling tower[2]	WWTP effluent
Aluminium	µg/L		< 500	36
Calcium	mg/L		>20 / <500	98
Carbon hardness	°dH		< 4 /< 20	
Chloride	mg/L		< 50 / < 250	167
Conductivity	µS/cm		50 - < 3000	1200
Copper	µg/L		< 500	6
E. Coli	CFU/100 mL; MPN/100mL	200	Absence	
Intestinal nematodes	eggs/10L	<1	< 1	
Iron	mg/L		< 0.1 / < 0.5	0.24
Legionella	CFU/L		< 100	
Magnesium	mg/L		< 100	11
pH			7 - 9	7.9
Sulphate	mg/L		< 50 / < 600	115
TDS	g/L		< 1.8	
Total Hardness	°dH		< 8	
TSS	mg/L	<20	< 5	7.1
Turbidity	NTU	<10	< 1	

[1]Royal Decree (1620/2007) (2007) Spanish Regulations for Water Reuse – Royal Decree 1620/2007 of 7 December. Madrid: Spanish Association for Sustainable Water Reuse ASERSA, Universitat Politècnica de Catalunya, UPC and Consorci de la Costa Brava, CCB.

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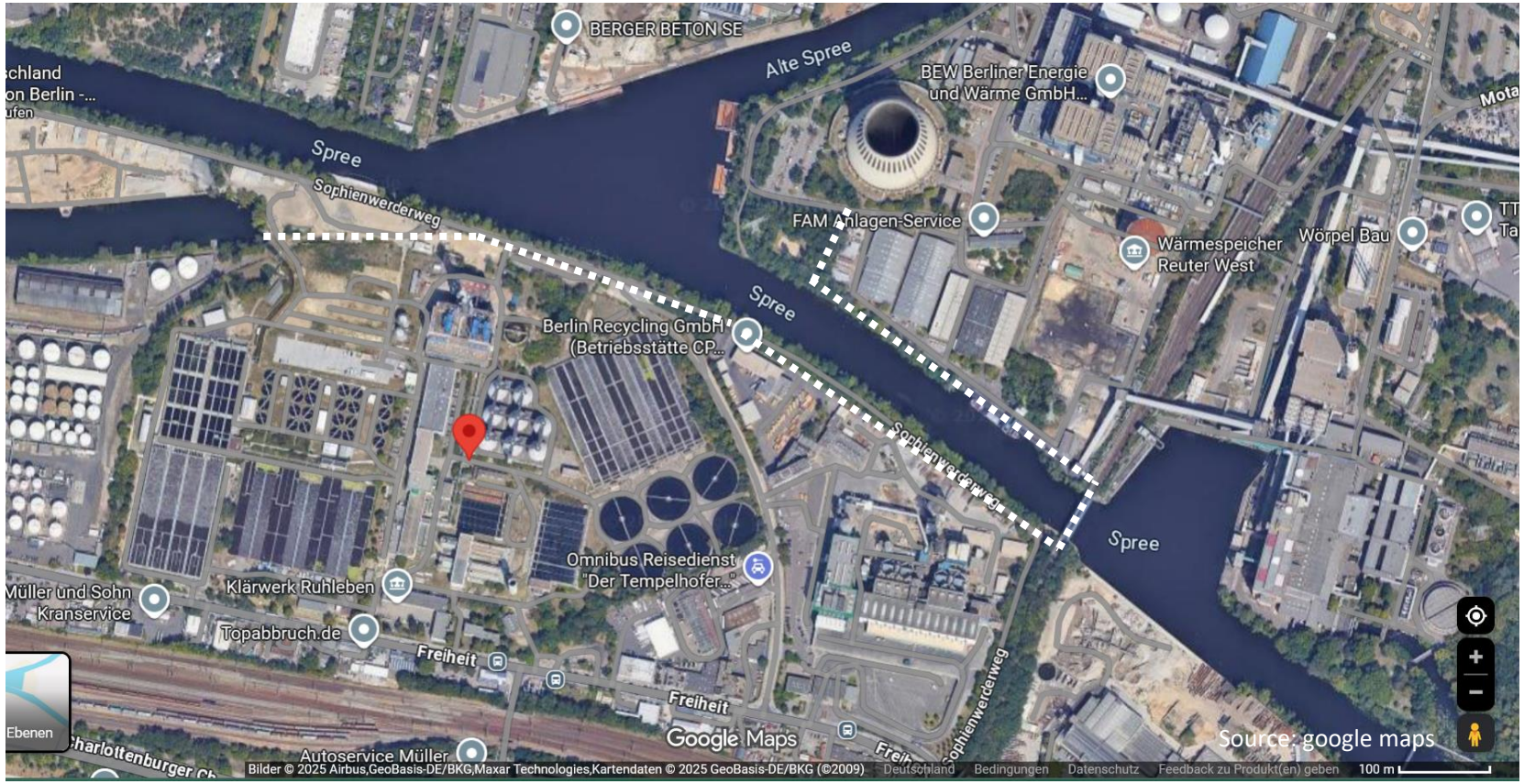
Pipeline costs – Example cooling tower

- Estimation for pipeline construction costs incl. Pavement works, excavation, material costs
- Cost estimate per m pipeline: 410€[1]
- Pipeline length: approx. 1550 m
- Estimated costs: 640,000€
- Excluding maintenance, pumping, operation



[1]Based on Wilmes & Heinrich (2022), considering a prize increase of 30%

Pipeline costs – Example cooling tower

- Estimation for pipeline construction costs incl. Pavement works, excavation, material costs
- Cost estimate per m pipeline: 410€[1]
- Pipeline length: approx. 1550 m
- Estimated costs: 640,000€
- Excluding maintenance, pumping, operation

- Estimated costs to Clean Car facility: 450,000€

Proximity is a key aspect for viable water reuse!

[1]Based on Wilmes & Heinrich (2022), considering a prize increase of 30%

WWTP Stahnsdorf

The context – WWTP Stahnsdorf

- Aim to assess the potential of reuse of municipal wastewater at WWTP Stahnsdorf
  - Focus on agricultural reuse
  - Urban irrigation may be included as well
- Close cooperation with Berlin water utility (BWB)
- Boundary conditions:
  - New WWTP will replace old WWTP by 2037
  - Assessment shall include current and future WWTP
  - Capacity current WWTP 410,000 p.e./50,000 m³/a
  - Capacity future WWTP 900,000 p.e./100,000 m³/a


Source: Berlin water utilities (BWB)

Stakeholders – WWTP Stahnsdorf

1. **Operators of the Treatment Facility & Municipal Wastewater Treatment Plant (public/private):**
   - BWB: Stahnsdorf Wastewater Treatment Plant
   - Water and Wastewater Association (WAZV) "Der Teltow“
   - Mittemärkische Wasser- und Abwasser GmbH (Service provider for WAZV "Der Teltow")
2. **Operators of Facilities for the Storage and Distribution of Treated Water (if applicable):**
   - See references (1) or (3).
3. **Operators Responsible for Irrigation** (Farmers/Agricultural Associations/Irrigation Associations):
   - e.g., Agro Saarmund GmbH
4. **Relevant Authorities:**
   - Water, Health & Environmental Authorities:
     - Primary responsible authority: Lower Water Authority – Landkreis Potsdam Mittelmark
     - Upper Water Authority – State Office for the Environment (LfU) Brandenburg
     - Health Department – Potsdam-Mittelmark District
   - Lower Nature Conservation Authority
   - Lower Soil Protection Authority
   - State Office for Rural Development, Agriculture, and Land Reorganization (Plant Protection)
5. **Other Stakeholders:**
   - Entities responsible for parts of the water and wastewater system or located within the affected area.
     - E.g. users of surfaces close to farm land to be irrigated

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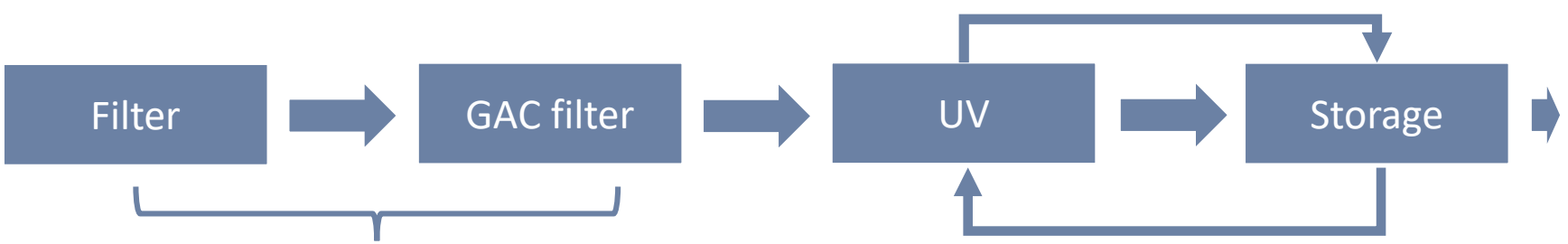
5. **Other Stakeholders:**
   - Entities responsible for parts of the water and wastewater system or located within the affected area.
     - E.g. users of surfaces close to farm land to be irrigated

Technical solution – favored option status quo

- Aim: Class B according to the Water reuse regulation 2020/741



- Agricultural irrigation
- Urban irrigation
- Process water for WWTP
- Discharge

Treatment capacity:
Q = 115 m³/h
Number of filters:
first stage = 2
Second stage GAC filter = 4

Treatment capacity:
Q = 115 m³/h

Storage:
V = 8000 m³
Number of storage tanks:
4 tanks

Process concept enables continuous operation
- Lower maintenance requirements
- Lower operating costs

Buffer storage tanks enable a reduction in treatment units
- 2 sand/solids filters and 4 GAK filters
- 1 UV disinfection

Treated water can be used for various purposes

Quantitative microbial risk assessment

Quantitative microbial risk assessment

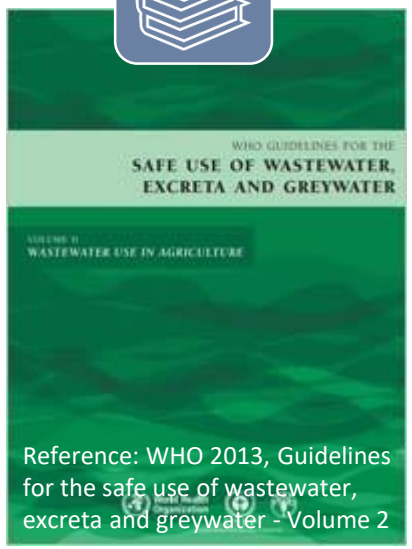
Aims & scope within WaterMan

1. Data collection of missing local data for real pathogens in wastewater to provide local data for a QMRA
2. Compare default data with local data and evaluate added value
3. Carry out a QMRA with local data for selected use cases with the QMRA tool
   - Industrial / commercial applications: cooling tower, car wash
   - Urban irrigation
   - Potentially: Agricultural irrigation at WWTP Stahnsdorf assuming similar *Campylobacter jejuni* concentrations

Additional sampling need is evaluated currently → QMRA not finished yet

Quantitative microbial risk assessment

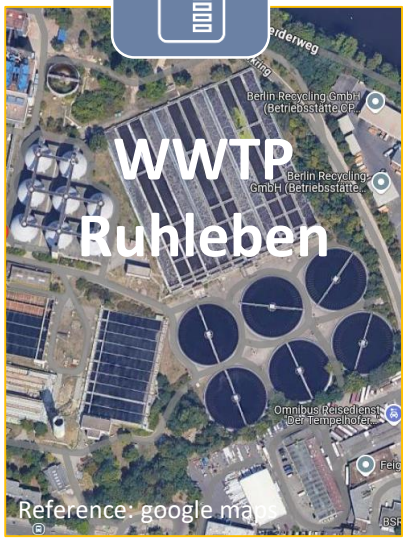
Default data



Reference: WHO 2013, Guidelines for the safe use of wastewater, excreta and greywater - Volume 2

VS.

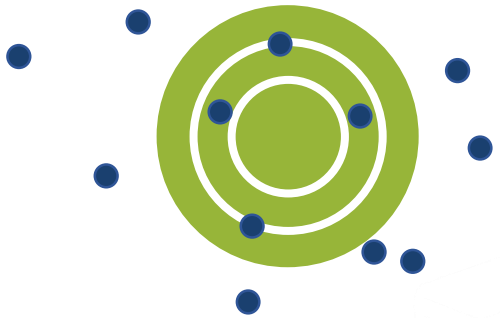
Local data



Reference: google maps

Quantitative microbial risk assessment

Default data



VS.

Local data

Is the effort for local data collection worth it?

Quantitative microbial risk assessment

Default data

Pros

- Low effort & quick access
- Cost-efficient (no lab analysis needed)
- Standardized, widely accepted
- Good starting point for feasibility studies

Cons

- Not site-specific → may not reflect local conditions
- Static values → no insight into variability or dynamics
- Risk of under/overestimating risks
- May reduce accuracy of decision-making
- Can weaken credibility if questioned by stakeholders

Local data

Pros

- Site-specific: reflects actual effluent characteristics
- Captures variability (seasonal, operational)
- Improves reliability of decisions and designs
- Stronger credibility with stakeholders/ regulators

Cons

- Higher effort (sampling, analysis) & more costly (lab fees, staff time)
- Requires planning & expertise
- Data may still be uncertain if sampling is limited
- Effort may not be justified if values are close to literature defaults
- Microbial analysis of real pathogens is challenging

Quantitative microbial risk assessment

Default data

- WWTP influent matrix: highly complex accompanying microbial flora
- Lab capacities; often methods need to be developed or fine tuned
- Costly: not standard parameters; e.g. 100-500€ per sample for *C. jejuni*
- Results are often not straight forward to interpret

Local data

Pros

- Site-specific: reflects actual effluent characteristics
- Captures variability (seasonal, operational)
- Improves reliability of decisions and designs
- Stronger credibility with stakeholders/ regulators

Cons

- Higher effort (sampling, analysis) & more costly (lab fees, staff time)
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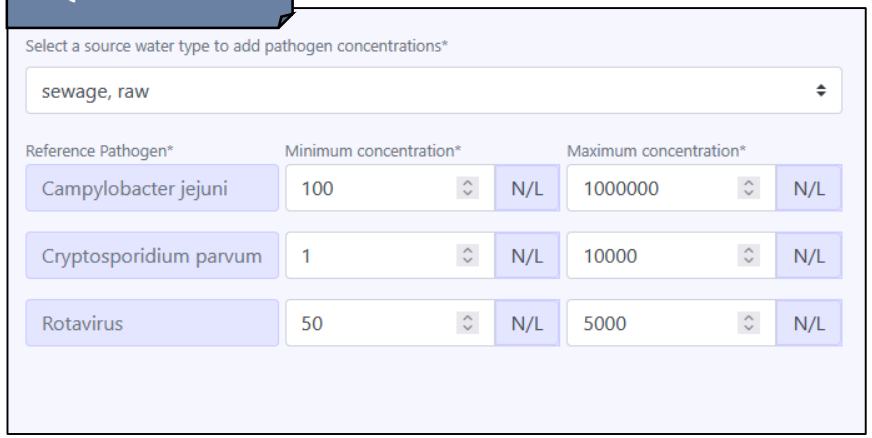
Quantitative microbial risk assessment

Default data

QMRA tool



Local data

pathogen	Range (n/L)	Reference
Campylobacter jejuni	<1,000 - 850,000	Own measurements
Cryptosporidium parvum	10,000 – 30,000	Selinka et al., 2019

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↑

Eftim et al., 2017: Occurrence of norovirus in raw sewage e A systematic literature review and meta-analysis; http://dx.doi.org/10.1016/j.watres.2017.01.017
Selinka et al., 2019: Viren und Parasiten in Abwasser und Flüssen sowie Handlungsempfehlungen für Flüsse mit kurzzeitigen Verschmutzungen, Abschlussbericht Flusshygiene, Umweltbundesamt

Key findings & Transferability

- Be flexible: adapt project scope change over time and in discussion with local stakeholders
- Differing level of interest depending on location
- Proximity is a key parameter for economic water reuse
- Creation of incentives is key: Difficult to find non-public large-scale end-users

Think local, apply broadly. Success depends on context, but lessons transfer widely.

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Thank you! Any questions?

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Access the „BSR Water Recycling Toolbox” here.
https://www.eurobalt.org/waterrecyclingtoolbox/

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The „BSR Water Recycling Toolbox” was elaborated as part of the project “WaterMan - Promoting water reuse in the Baltic Sea Region through capacity building at local level”, The project is co-financed by the European Union (European Regional Development Fund) and implemented within the Interreg Baltic Sea Region Programme. More information:

eurobalt.org/WaterRecyclingToolbox
interreg-baltic.eu/project/waterman

WaterMan promotes a region-specific approach to water recycling, which intends to use the alternation of too much and too little water that has become typical in the Baltic Sea Region to make the local water supply more resilient, and supports municipalities & water companies in adapting their strategies.

The contents of „BSR Water Recycling Toolbox” are the sole responsibility of the authors and can in no way be taken to reflect the views of the European Union, the Managing Authority or the Joint Secretariat of the Interreg Baltic Sea Region Programme.