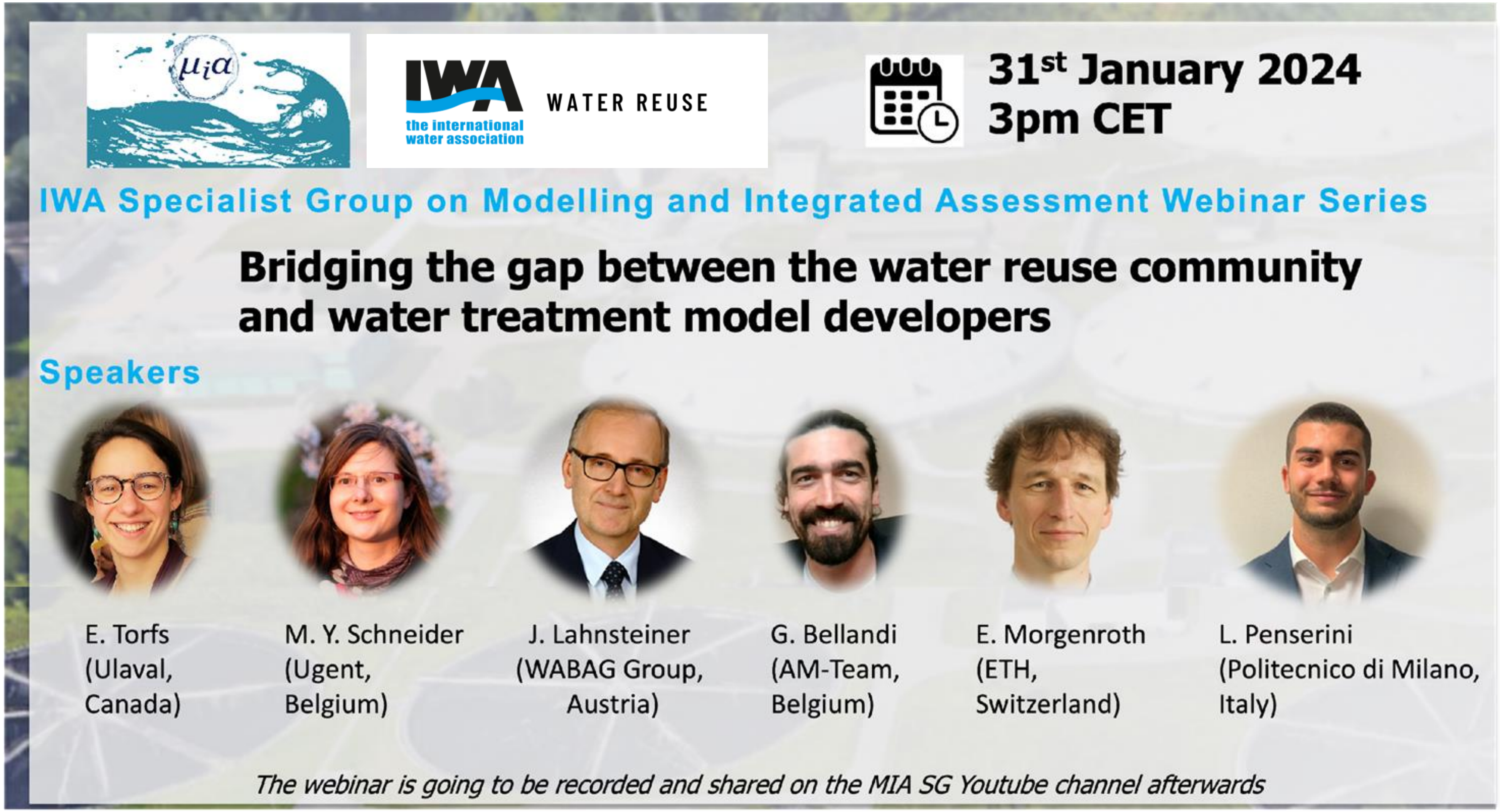
WATER REUSE



inspiring change

AGENDA AND HOUSEKEEPING

Introduction to specialist groups
Elena Torfs (ULaval, CA, chair modelling and integrated assessment)
Josef Lahnsteiner (Wabag, AT, chair water reuse)

Water reuse
Josef Lahnsteiner (Wabag, AT)

Process models
Giacomo Bellandi (AM-Team, BE)

Microbial risk assessment
Eberhard Morgenroth (EAWAG, CH)

Impact assessment models
Luca Penserini (PoliMi, IT)

Q&A Session Moderator: *Mariane Schneider (UGent, BE)*

- This session is being recorded;
- Please do not use the chat function.
- Please put any questions and comments you may have in the Q&A and we will do our best to answer them during the session (in writing or orally).
- Microphones and cameras have been disabled due to the large number of attendees.

Upcoming events and deadlines

- **February 1st**, extended deadline for abstract submission to the “International Conference On Wider- Uptake Of Water Resource Recovery From Wastewater Treatment” in Palermo, Italy.

- **February 5th**, webinar on good coding practice in water resource recovery facilities: hands-on session.

- **May 5th**, abstract submission deadline for the “14th IWA International Conference on Water Reclamation and Reuse” in Cape Town, South Africa.

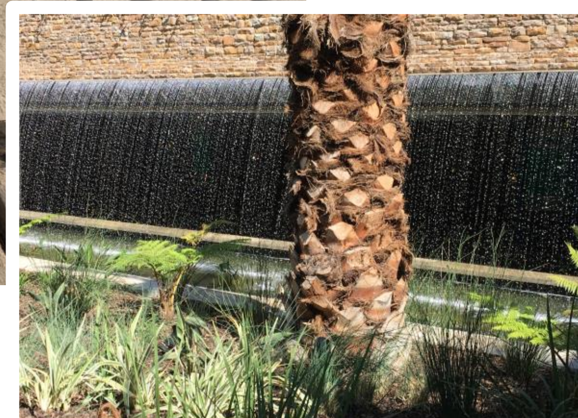
Find out more at

http://iwa-mia.org/

https://iwa-connect.org

IWA Water Reuse Specialist Group

INTRODUCTION AT THE MIA & WR SG WEBINAR, 31 JANUARY 2024



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WATER REUSE SPECIALIST GROUP

- The Water Reuse Specialist Group (WRSG) is globally the leading forum in water reclamation and reuse, and is the largest Specialist Group of IWA
- Our major aim is the implementation of safe water reuse practice through the promotion of successful water reuse projects and sharing of information via our international knowledge network, specialist conferences and website

Courtesy City of Windhoek

IWA INTERNATIONAL CONFERENCES ON WATER RECLAMATION AND REUSE

the international water association

- 1st International Conference, Costa Brava, Spain, 1991
- 2nd International Conference, Iraklion, Greece, 1995
- 3rd International Conference, Paris, France, 2000
- 4th International Conference, Mexico City, Mexico, 2003
- 5th International Conference, Jeju Island, Korea, 2005
- 6th International Conference, Antwerp, Belgium, 2007
- 7th International Conference, Brisbane, Australia, 2009
- 8th International Conference, Barcelona, Spain, 2011
- 9th International Conference, Windhoek, Namibia, 2013
- 10th International Conference, Harbin, China, 2015
- 11th International Conference, Long Beach, USA, 2017
- 12th International Conference, Berlin, Germany, 2019
- 13th International Conference, Chennai, India, 2023
- 14th International Conference, 2025, Cape Town, 2025
- 15th International Conference, 2027, Call in Q4 2024

WATER REUSE SPECIALIST GROUP WEBINARS IN 2022

the international water association

“On the Road to Chennai 2023” Webinar Series

- ***Water Reuse in the USA – A Trend on the Rise***
  on 15 February 2022, organised by Melissa Meeker et al.
  Water Reuse in the United States: A Trend on the Rise - International Water Association (iwa-network.org)

- ***Industrial Water Reuse: Perspectives from Emerging Countries***
  on 26 April 2022, organised by Olivier Lefebvre et al.
  Industrial Water Reuse: Perspectives from Emerging Economies - International Water Association (iwa-network.org)

- ***"Water Reuse Applications across Industries in Advanced Economies***
  hosted jointly with the WateReuse Association on 12 May 2022
  Water Reuse Applications Across Industries in Advanced Economies - International Water Association (iwa-network.org)

- ***Advancements in Microbiological Safety for Potable Reuse*** organized in cooperation with the IWA Health Related Water Microbiology Specialist Group on July 27 2022
  Advancements in Microbiological Safety for Potable Water Reuse - International Water Association (iwa-network.org)

13TH IWA INTERNATIONAL CONFERENCE ON WATER RECLAMATION AND REUSE

the international water association

14TH IWA INTERNATIONAL CONFERENCE ON WATER RECLAMATION AND REUSE

Schedule

Action	Timeline
Call for abstracts	End of February 2024
Abstract submission deadline	05 May 2024
Review of the submitted abstracts	May and June 2024
Authors notification	Mid-July 2024
Publication of the program	15 October 2024
Start of online registration	Mid-November 2024
Full paper submission deadline	Mid-January 2025
Deadline for appearance in the printed list of participants	Mid-February 2025
Conference	16 to 20 March 2025

Newsletters in 2022 and 2023

Editor: Michael Muston

- April 2022
- September 2022
- December 2022
- May 2023
- October 2023

Can be downloaded from IWA CONNECT PLUS

WATER REUSE SPECIALIST GROUP

Working Groups

- Young Water Reuse Professionals (YWRP), Stevo Lavrnić
- Agricultural irrigation, Jeff Mosher
- Industrial reuse, Olivier Levebvre
- Urban landscape irrigation and other non-potable reuse practices, Maria João Rosa
- Potable water reuse, Jörg Drewes
- Desalination, Paul Schausberger
- Reuse in developing countries, Akiça Bahri
- Water quality management and water reuse guidelines, Shane Snyder
- Social and economic dimensions of water reuse, Melissa Meeker

Contact: Samendra Sherchan samendra.sherchan@morgan.edu

Thanks for your attention!

Josef.lahnsteiner@wabag.com
Director Technology, R&D of WABAG Group
Chair Water Reuse Specialist Group

MIA & WR SGs Webinar | Bridging the Gap between Water Reuse and Water Treatment Model Developers | 31 January, 2024

Water reuse – a brief overview

Josef Lahnsteiner

Director Technology, R&D of WABAG Group

Chair IWA Water Reuse Specialist Group

Outline

- Introduction
- Reuse of treated municipal secondary effluent in various industries, Chennai, India
- Overview on indirect and direct potable water reuse (IPR & DPR) projects
- Reuse of treated municipal secondary effluents for direct potable reuse (DPR) at Windhoek, Namibia
- Conclusions

Introduction

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Drivers for water reuse and recycling

- Water shortage caused by
  - Climate change
  - Population growth
  - Urbanization
  - Industrialization in developing and emerging economies
- Economic reasons
  - Lower fresh water demand
  - Lower energy demand (e.g. transport from distant sources can be very energy and cost-intensive)
  - Reduced wastewater discharge and subsequently reduced discharge fees
  - Resource recovery
- Boost in water supply security – used water (wastewater) is a drought-proof resource
- Policies, regulations and guidelines
  - EU Regulation on Minimum Requirements for Water Reuse, 2020
  - A Proposed Framework for Regulating Direct Potable Reuse in California 2019 (2^{nd} Edition)
  - Treated Wastewater Reuse Policy for Tamil Nadu, India, 2019
  - Potable Reuse – Guidance for Producing Safe Drinking Water, WHO 2017
  - GB 50335 – Code for Design of Wastewater Reclamation and Reuse, China, 2017 (2^{nd} Edition)
  - Irrigation Water Quality Standards of the Royal Commission Environmental Regulation, KSA 2015

City of Chennai

- Capital city of Tamil Nadu
- Fourth largest city in India
- Population - 7 million (Chennai City), 11 million (metropolitan area)
- One of the world fastest growing economies
- Automotive hub of India
- Further major industries
  - Textiles
  - Petrochemicals
  - Fertilizers
  - Electronics hardware

Google Maps 2016

City of Chennai

Drought in 2019

- Summer monsoon appeared to fail
- Worst drought in history
- Freshwater reservoirs were empty
- State of emergency (comparable to Cape Town)
- Drinking water had to be supplied by government tankers
- Even hospitals had a lack of water - non-acutely necessary operations were postponed

Chennai, Koyambedu Water Reclamation Project

Key Facts

- Location Chennai, India
- Client Chennai Metro
- Project type DBO
- Capacity 45,000 m³/d
- Start-up End of 2019
- O&M 2019 - 2034

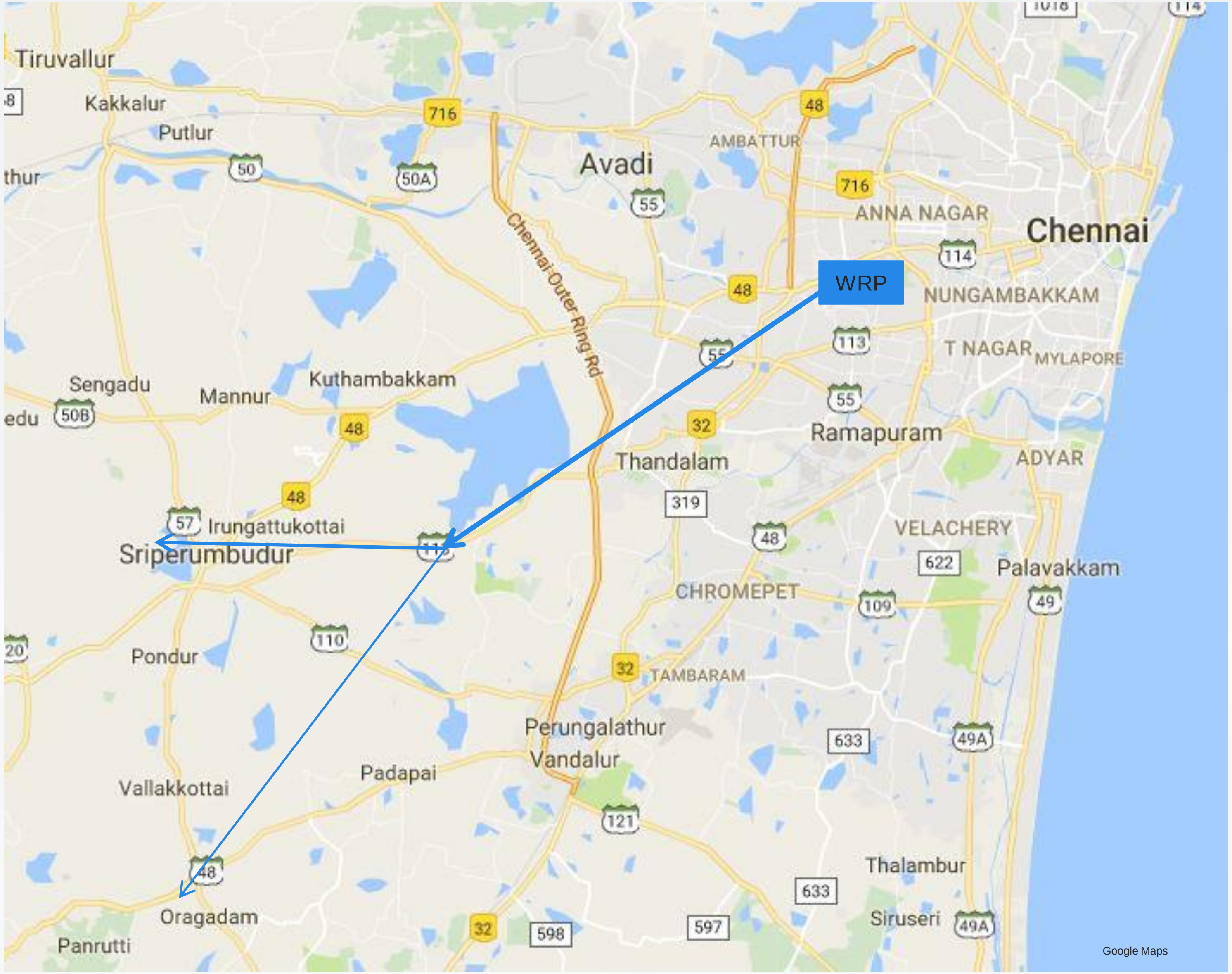
- Advanced multiple barrier system

- Reuse of reclaimed water in various industries

Raw water (secondary effluent) and reclaimed water quality

Main parameters	Unit	Raw water	Reclaimed water
BOD	mg/L	20	BDL
COD	mg/L	160	BDL
Total dissolved solids (TDS)	mg/L	1,500	< 70
Total silica (as reactive SiO_2)	mg/L	40	< 5

Koyambedu Water Reclamation Project



The aim is to boost the overall water supply security by industrial reuse

Distribution network (simplified)

Koyambedu Water Reclamation Plant

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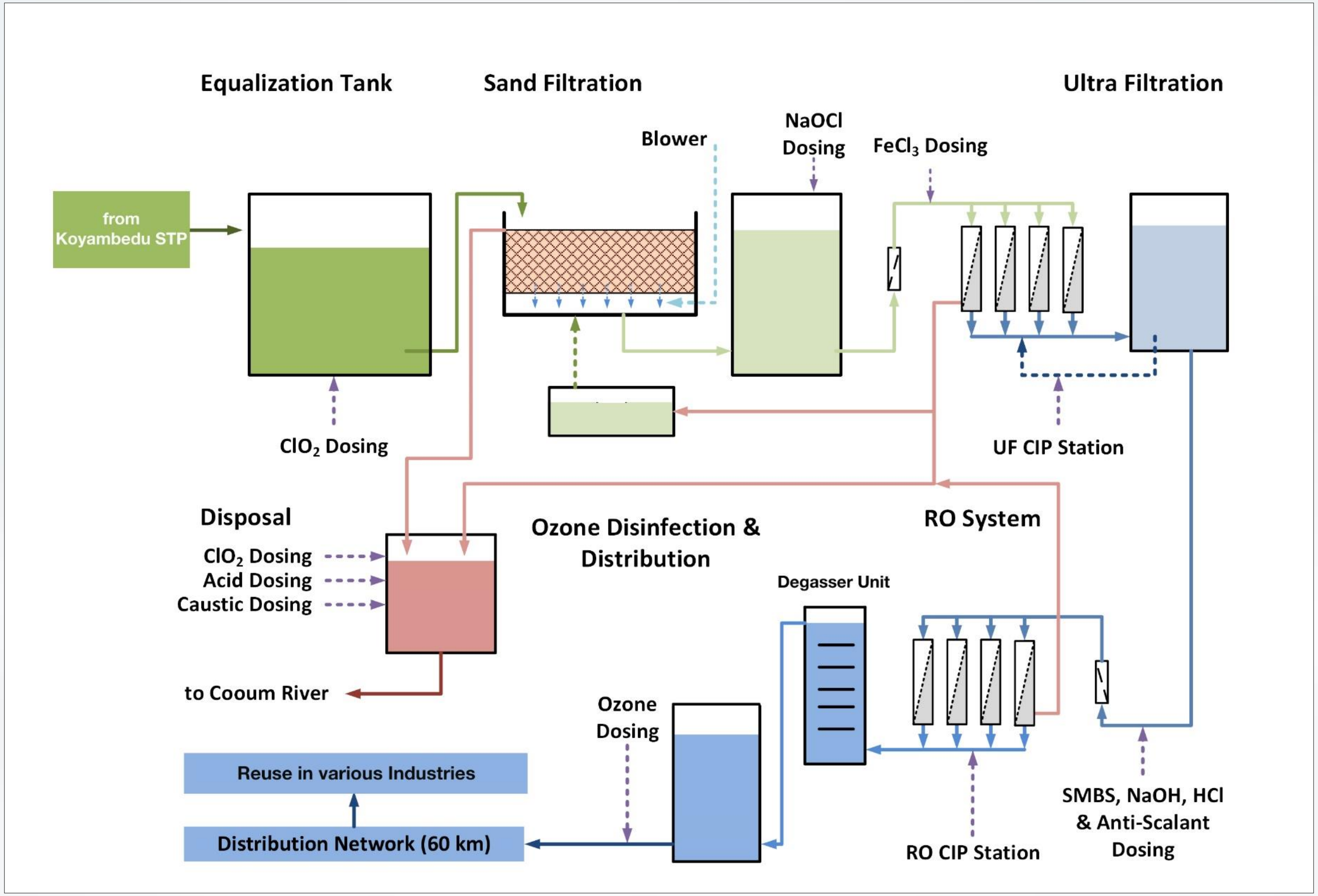

Simplified Process Flow Diagram

Koyambedu Water Reclamation Plant

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Ultrafiltration (Inge Dizzer XL 0.9 MB 70 WT

Koyambedu Water Reclamation Plant

Reverse Osmosis Units (Dow BW30XFR-40034i), Q = 45,000 m^3/d permeate

Koyambedu Water Reclamation Plant

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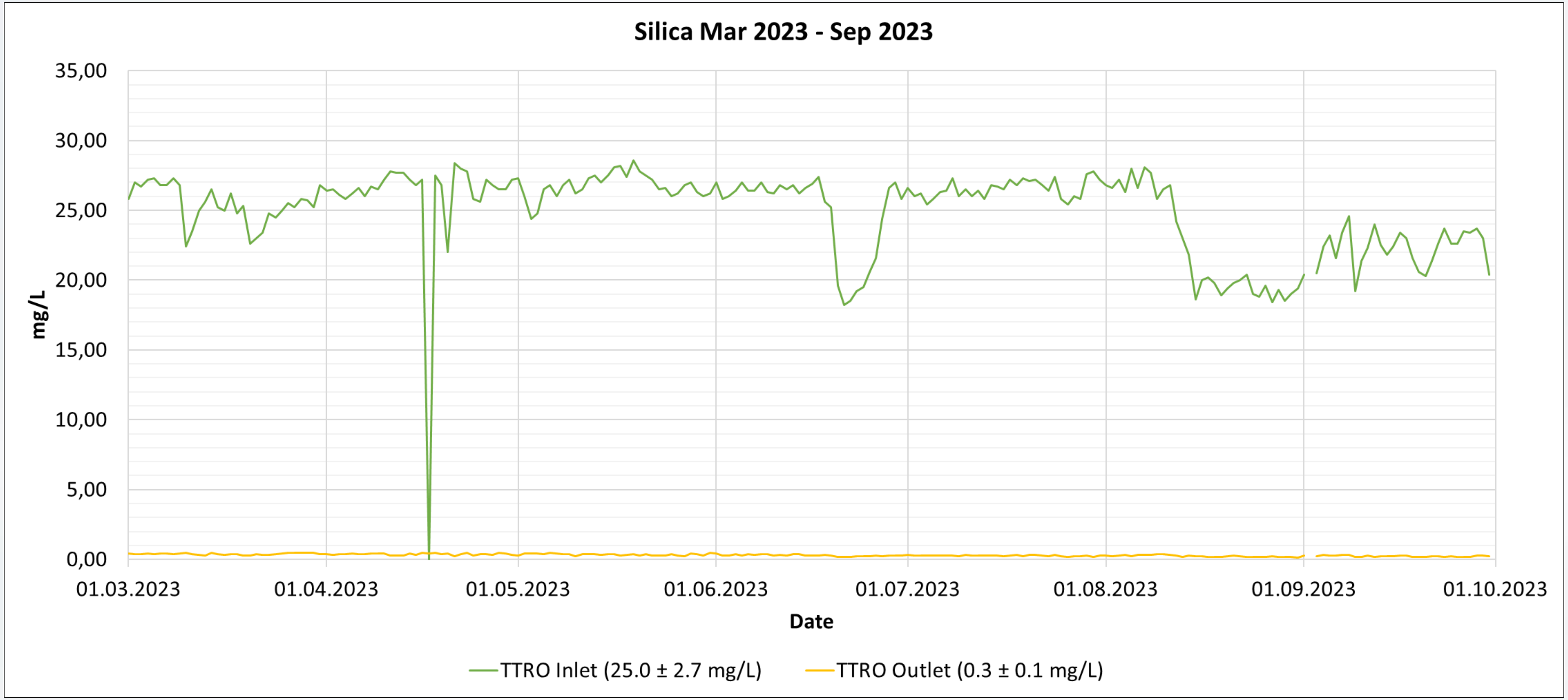
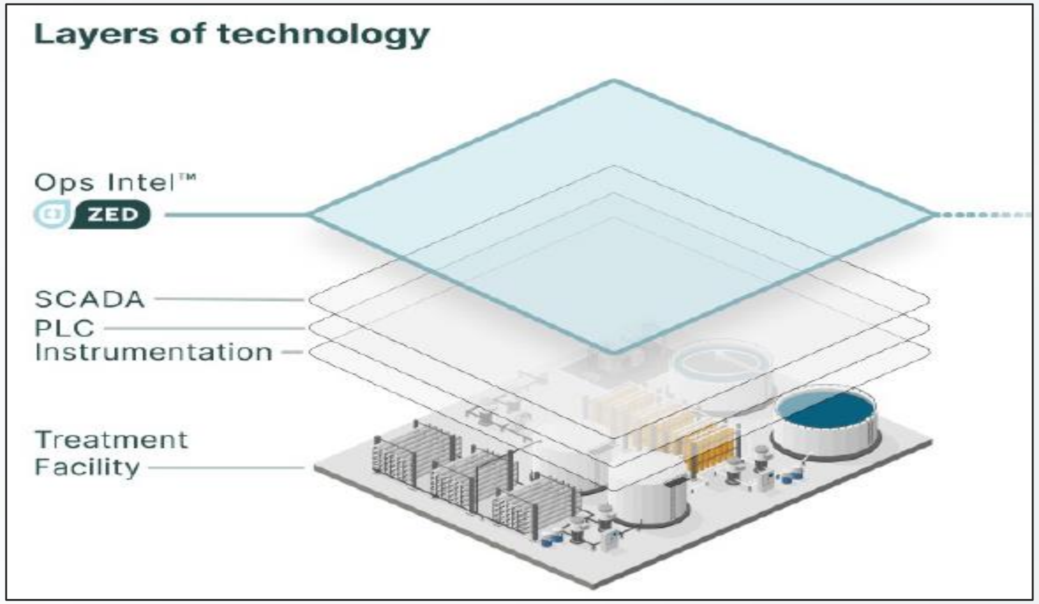


Removal of silica

Operating Intelligence Tool for OPEX Reduction– Pilot Project

An operating intelligence tool (Pani ZED) interacts with the PLC and SCADA system and helps to improve the quality of higher impact decisions that need to be made by the plant operation team



Consultation

24/7 expert consultation on optimization opportunities

Guidance

Guidance on addressing the detected issues and see where maintenance is required to plan ahead

Optimizing with AI

Prioritization

Prioritization of issues to unlock value for the operations

Data Management

Will provide the consolidated view of the data (data analytics)

Centralize Data

Operating Intelligence Tool for OPEX Reduction – Pilot Project

Issues & Challenges	Opportunities	Value & Cost Savings
Suboptimal membrane service timing through scheduled cleaning procedures	Predictive model provides recommendations for optimized membrane cleaning	Longer uptime & membrane life, chemical & energy savings
Reactive (non-proactive) problem detection through alarms	An expert system with automatic fault detection and diagnostics provides recommendations for proactive intervention	Longer uptime & savings in equipment and troubleshooting time (by predictive maintenance)
Use of static projection tools for chemical dosing	Provision of dynamic set points for optimized dosing based on multi-signal decisions by using e.g. anti-scalant models	Chemical savings, extension of membrane life
Usage of log sheets and manual assessment for decision making and reporting	Process driven decision templates for the plant to derive daily decions leading to simplified operations	Longer uptime, overall better plant performance, OPEX reduction

Pilot Project for RO Concentrate Treatment

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Removal of
- Recalcitrant COD
- Micro-pollutants (MP)
- Antimicrobial Resistance (AMR)

MBBR 1
Bio-stage I

Ozone Unit

MBBR 2
Bio-stage II

Major Indirect Potable Reuse (IPR) Projects

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- Orange County Water District, CA/USA, Water Factory 21 (1976), Ground Water Replenishment System (2008), Q = 492,000 m^3/d (2023)
- Toreele/St-Andre, Belgium, managed aquifer recharge (2002), Q = 20,000 m^3/d
- Singapore NEWater, Kranji (2003), Bedok (2003), Ulu Padan (2007), Changi (2010, 2018 & 2023), Tuas (2025)
- Perth, Australia, groundwater replenishment (2017/2022), Q = 14/18 million m^3/a
- San Diego, CA/USA, phase two, Q = 200,000 m^3/d, pre-construction stage
- Bangalore V-Valley, India, postponed

Major Direct Potable Reuse (DPR) Projects

- Windhoek, Namibia (1968; OGWRP), (2002; NGWRP), Q = 21,000 m^3/d
- Beaufort West, South Africa (2011), Q = 2,000 m^3/d
- Big Spring TX/USA – Blending operation started in May 2013, Q = 8,000 m^3/d
- Wichita Falls, TX/USA – Mid 2014 to mid 2015 (emergency operation), Q = 19,000 m^3/d
- El Paso TX/USA – Pilot testing completed, full-scale *Advanced Water Purification Facility* in pre-construction stage, expected start-up 2026, Q = 40,500 m^3/d
- Cape Town, South Africa, Faure WRP, Q = 50,000/70,000 m^3/d, design stage, expected start-up 2027
- Windhoek, Namibia, Gammams WRP (DPR 2), Q = 20,000 m^3/d, pre-design stage, expected start-up 2028

Windhoek, Namibia

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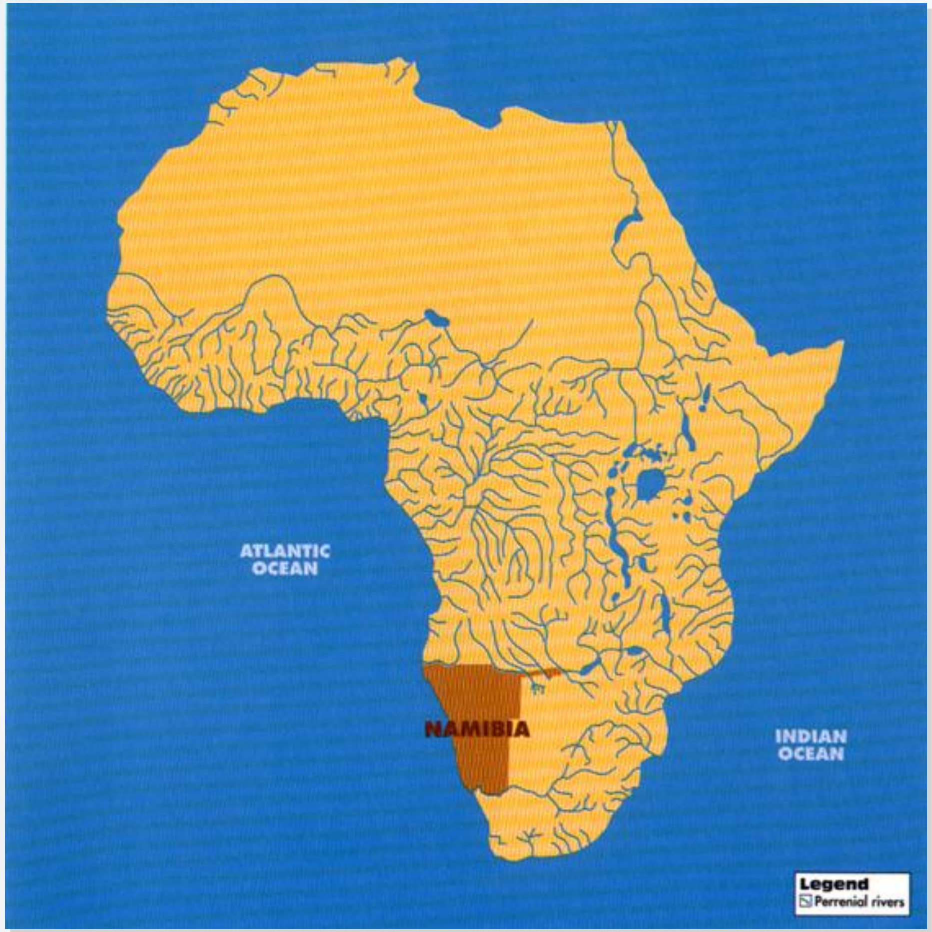

Courtesy City of Windhoek

Direct Potable Reuse in Windhoek, Namibia

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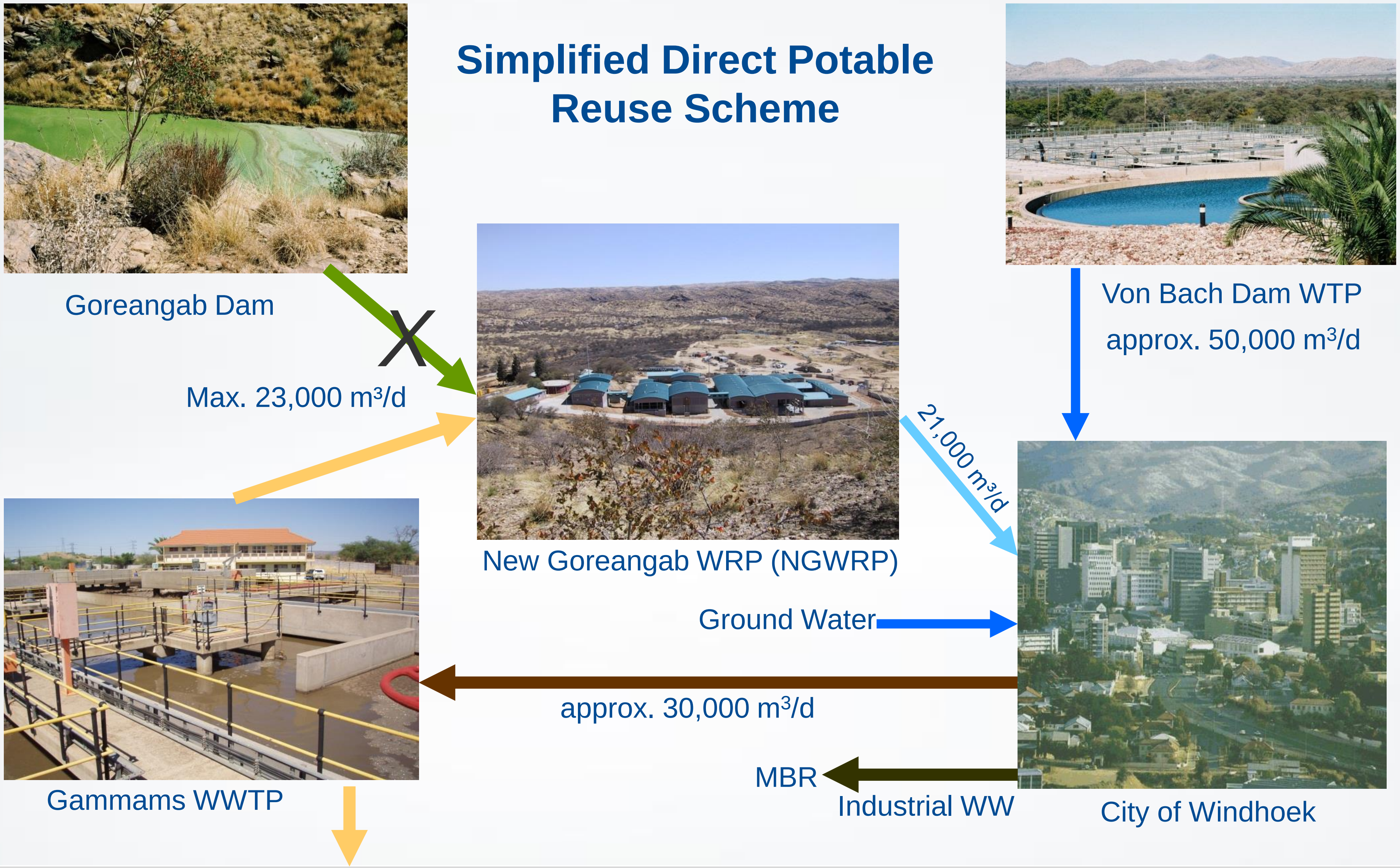

New Goreangab Water Reclamation Plant

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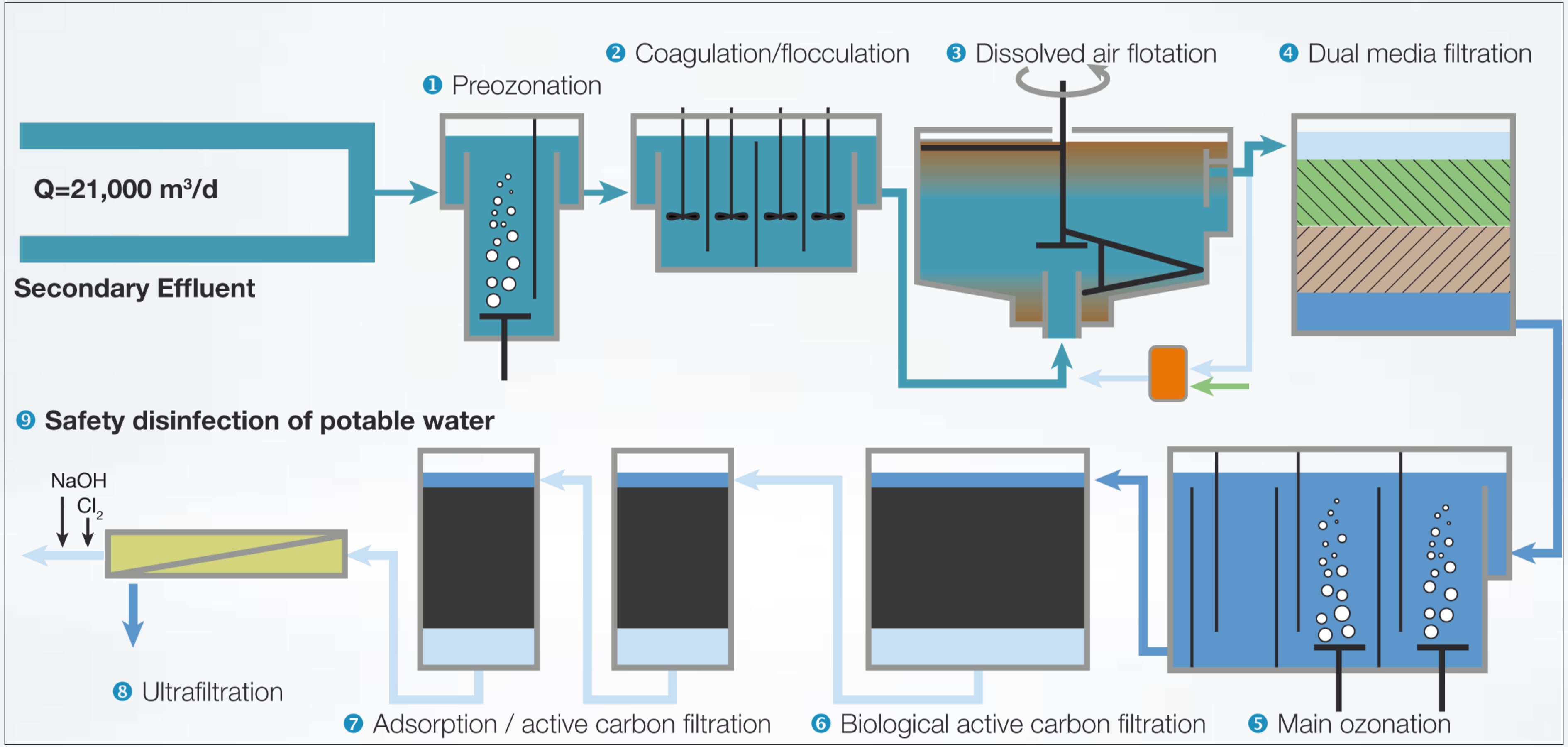

Simplified process flow diagram

- Modelling of MP and AMR removal would be interesting in particular for designing of such plants

New Goreangab Water Reclamation Plant

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Courtesy City of Windhoek

Direct Potable Reuse in Windhoek

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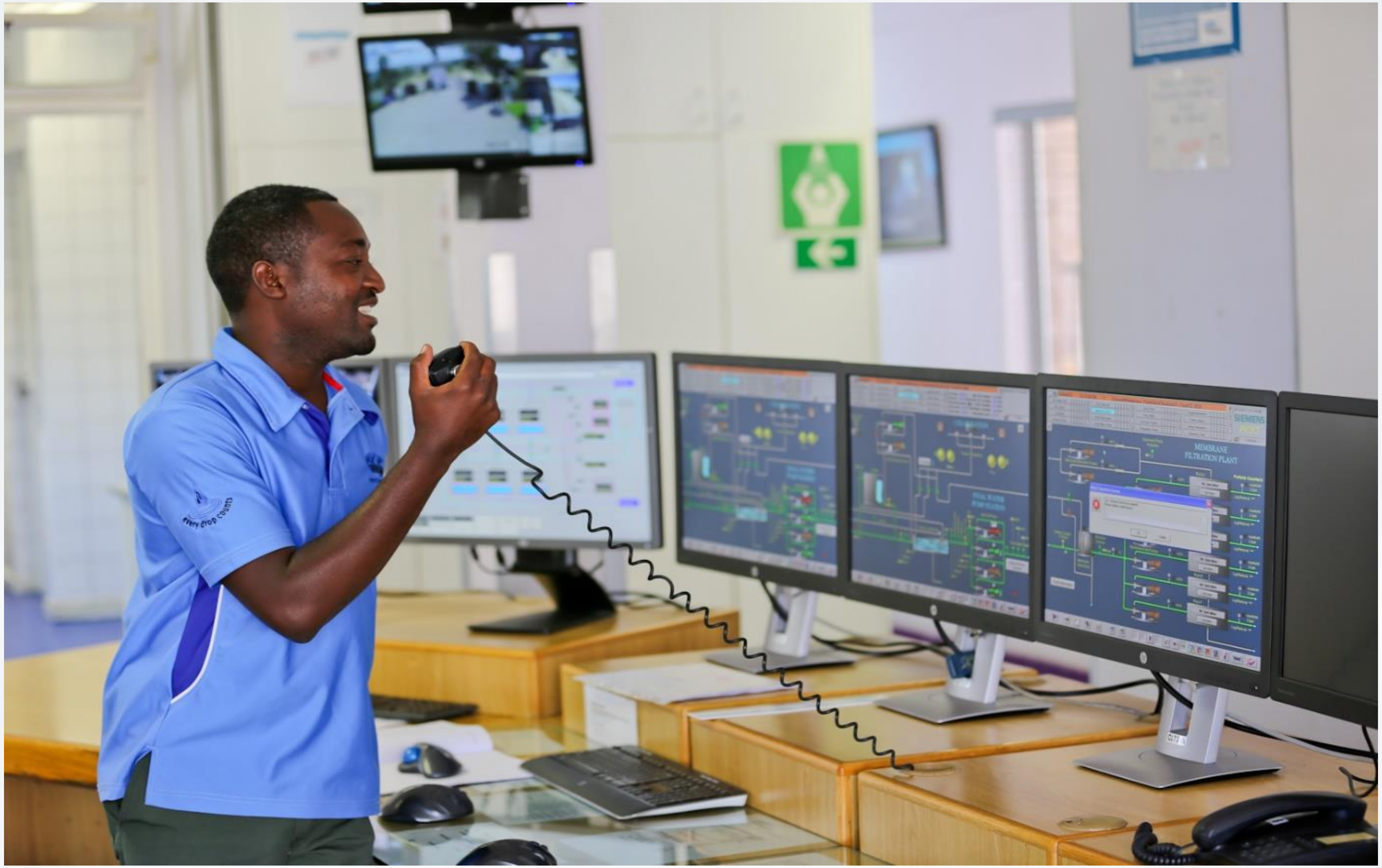
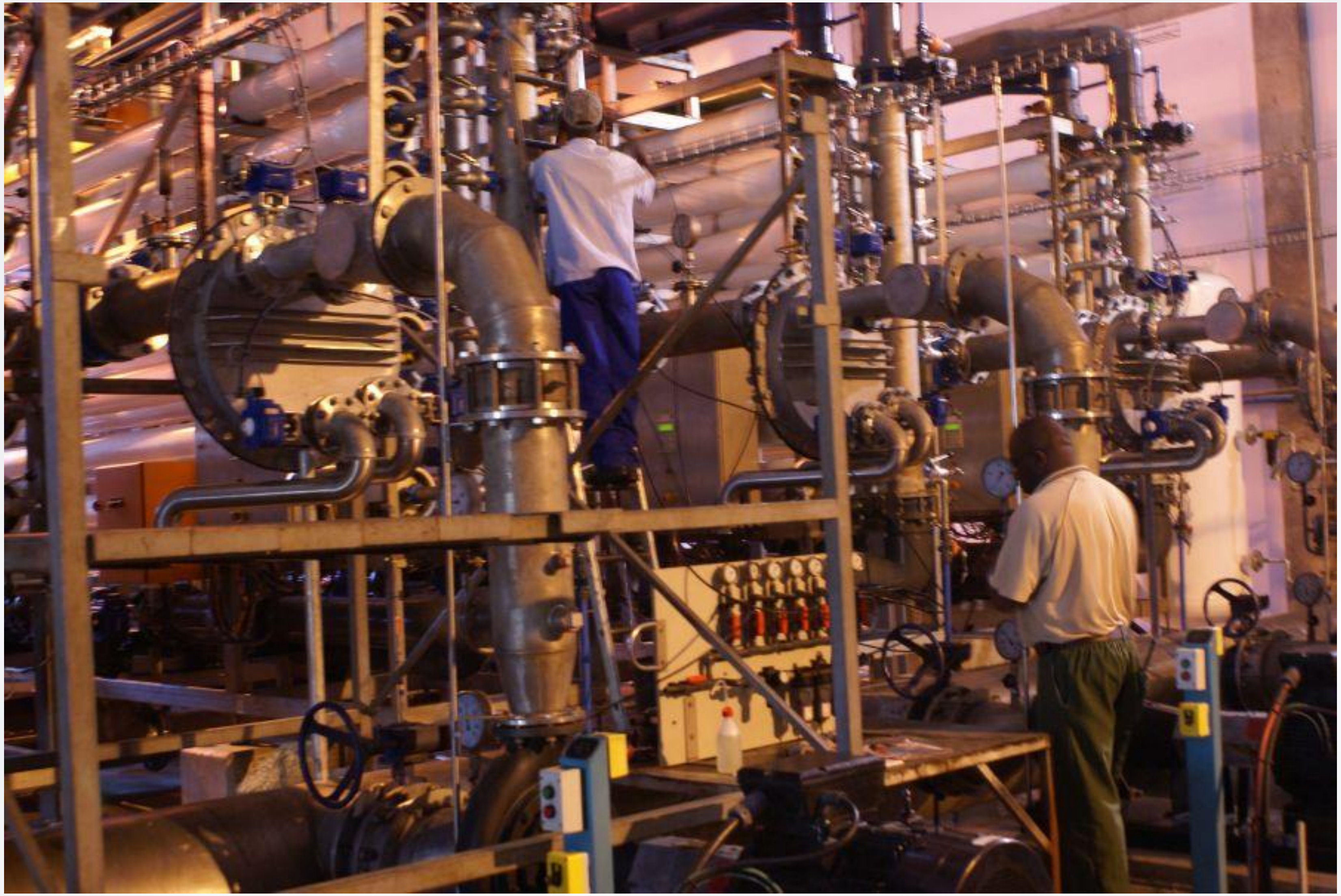


Courtesy WINGOC

NGWRP – Process surveillance with the SCADA system

Direct Potable Reuse in Windhoek



NGWRP – Ultrafiltration maintenance

Direct Potable Reuse in Windhoek

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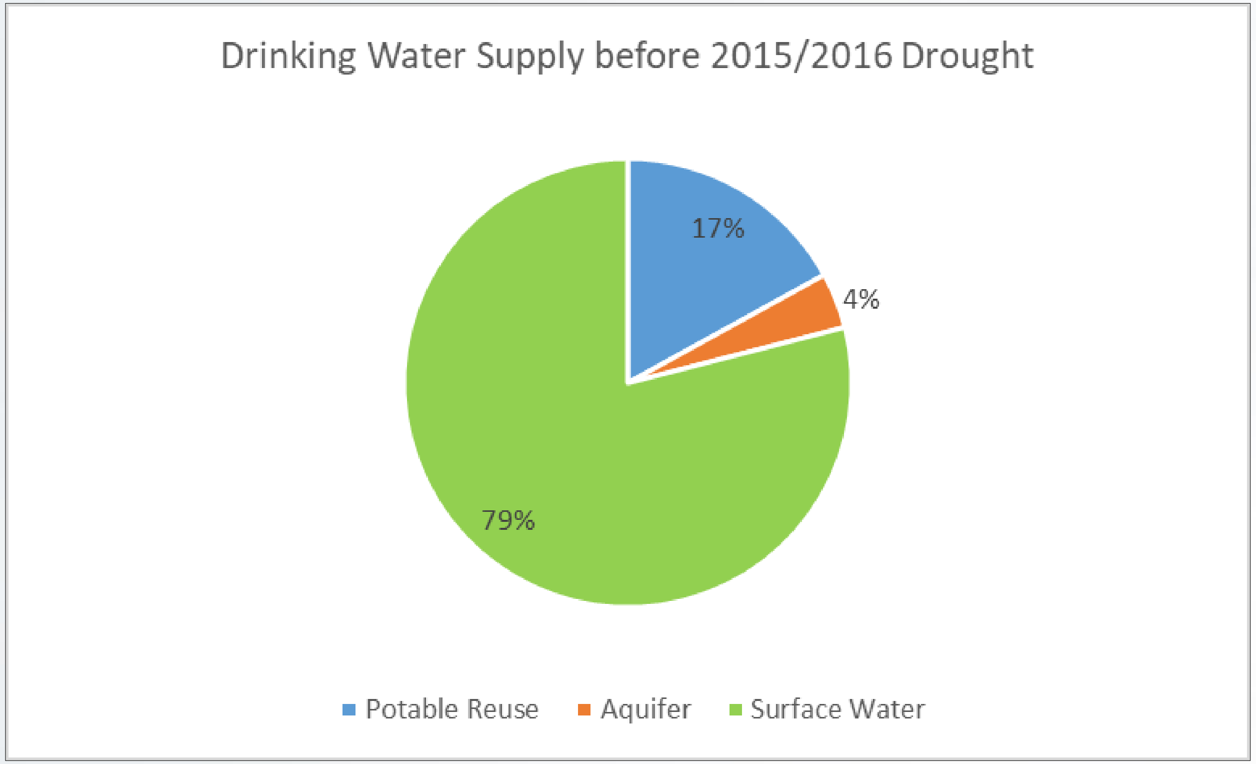
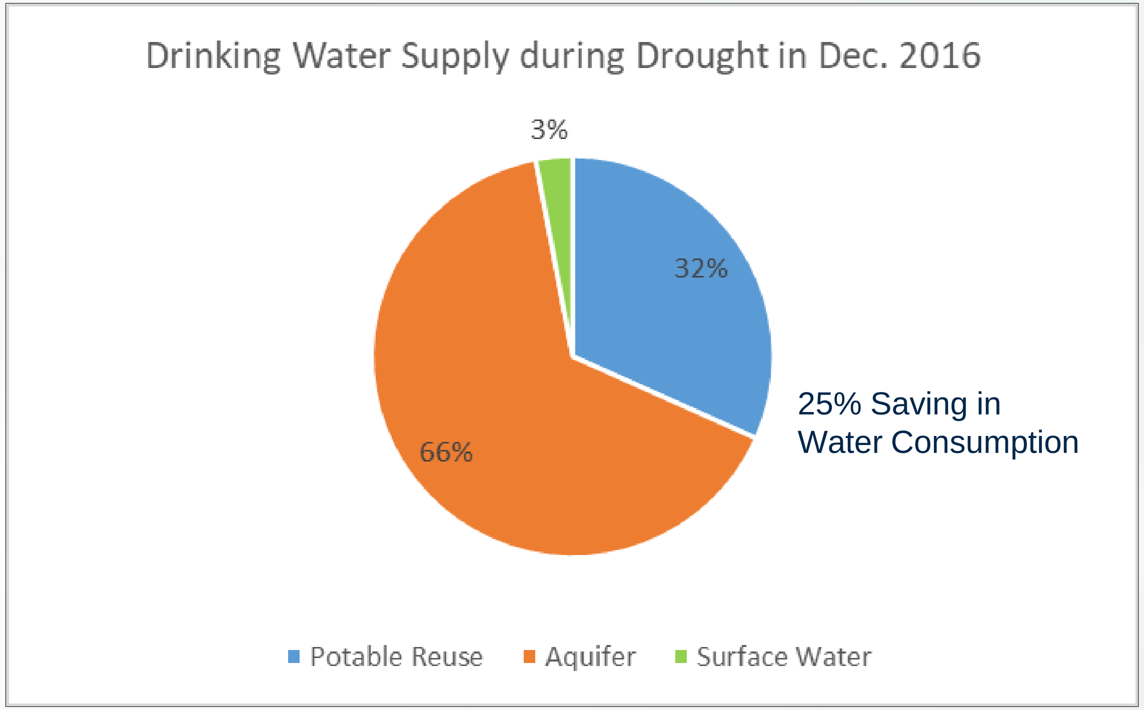
Windhoek's drinking water supply before and in last phase of the 2015/16 Drought





Modified after Pierre van Rensburg

➢ The quality of the reclaimed water is superior to that of the treated dam water

Development of Windhoek

- **Direct potable reuse has been essential for the social, economic and environmental development of the city**
  - **1990 — 140,000 inhabitants**
  - **2023 — 477,000 inhabitants**

Courtesy City of Windhoek

Conclusions

- Water reuse and recycling is mainly driven by water shortage and subsequently by economic and supply security reasons
  - Water reuse is cheaper than other options (seawater desalination, fresh water from distant sources, etc.)
  - Overall water supply security is boosted
- Concentrate management is gaining in importance
- The environmental impact can be substantially reduced
- In our view, modelling and integrated assessment have a high future potential to improve treated water quality and reduce operating expenditures
- Finally, it can be concluded that water reuse is a key element in social, economic and ecologic sustainability

Thank you for your attention!

josef.lahnsteiner@wabag.com

Back-up

Direct Potable Reuse in Windhoek

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Comparison between reclaimed water and treated dam water

Parameter	Unit	Treatment plants	
		NGWRP 2022	Von Bach Dam WTP 2022
Turbidity	NTU	0.1	0.5
DOC	mg/L	1.4	5.1
THM	µg/L	19	73
UV_{254}	abs/cm	0.03	0.07
TDS	mg/L	909	193

ETH zürich

Modeling Microbial Risks in Water Reuse

Eberhard Morgenroth, ETH and Eawag (Switzerland)

Webinar, January 31, 2024

eberhard.morgenroth@ifu.baug.ethz.ch

Modeling of wastewater treatment for environmental protection

Treatment

IWA Activated Sludge Models

Table 2 Process kinetics and stoichiometry for carbon oxidation, nitrification, and dentrification

j	Component → i / Process ↓	1 S_I	2 S_S	3 X_I	4 X_S	5 $X_{B,H}$	6 $X_{B,A}$	7 X_P	8 S_O	9 S_{NO}	10 S_{NH}	11 S_{ND}	12 X_{ND}	13 S_{ALK}	Process Rate, ρ_j $[ML^{-3}T^{-1}]$
1	Aerobic growth of heterotrophs		$-\frac{1}{Y_H}$			1			$-\frac{1-Y_H}{Y_H}$		$-i_{XB}$			$-\frac{i_{XB}}{14}$	$\hat{\mu}_H\left(\frac{S_S}{K_S+S_S}\right)\left(\frac{S_O}{K_{O,H}+S_O}\right)X_{B,H}$
2	Anoxic growth of heterotrophs		$-\frac{1}{Y_H}$			1				$-\frac{1-Y_H}{2.86Y_H}$	$-i_{XB}$			$\frac{1-Y_H}{14\cdot 2.86Y_H}-i_{XB}/14$	$\hat{\mu}_H\left(\frac{S_S}{K_S+S_S}\right)\left(\frac{K_{O,H}}{K_{O,H}+S_O}\right)\times\left(\frac{S_{NO}}{K_{NO}+S_{NO}}\right)\eta_g X_{B,H}$
3	Aerobic growth of autotrophs						1		$-\frac{4.57-Y_A}{Y_A}$	$\frac{1}{Y_A}$	$-i_{XB}-\frac{1}{Y_A}$			$-\frac{i_{XB}}{14}-\frac{1}{7Y_A}$	$\hat{\mu}_A\left(\frac{S_{NH}}{K_{NH}+S_{NH}}\right)\left(\frac{S_O}{K_{O,A}+S_O}\right)X_{B,A}$
4	'Decay' of heterotrophs				$1-f_P$	-1		f_P					$i_{XB}-f_P i_{XP}$		$b_H X_{B,H}$
5	'Decay' of autotrophs				$1-f_P$		-1	f_P					$i_{XB}-f_P i_{XP}$		$b_A X_{B,A}$
6	Ammonification of soluble organic nitrogen										1	-1		$\frac{1}{14}$	$k_a S_{ND} X_{B,H}$
7	'Hydrolysis' of entrapped organics		1		-1										$k_h \frac{X_S/X_{B,H}}{K_X+(X_S/X_{B,H})}\left[\left(\frac{S_O}{K_{O,H}+S_O}\right)+\eta_h\left(\frac{K_{O,H}}{K_{O,H}+S_O}\right)\left(\frac{S_{NO}}{K_{NO}+S_{NO}}\right)\right]X_{B,H}$
8	'Hydrolysis' of entrapped organic nitrogen											1	-1		$\rho_7(X_{ND}/X_S)$

COD

NO_3^-

Alkalinity

NH_4^+

Active biomass fractions

…PO_4^{3-}

Effluent requirements for discharge into receiving waters

COD

NO_3^-

NH_4^+

PO_4^{3-}

Organic micropollutants

Microbial safety for water reuse?

→ **Take home message:** State variables in activated sludge models are directly relevant for evaluating effluent quality and process performance

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Water quality target for water reuse: E. coli as indicator

Table 2 – Reclaimed water quality requirements for agricultural irrigation

Reclaimed water quality class	Indicative technology target	Quality requirements			
		E. coli (number/100 ml)	BOD_5 (mg/l)	TSS (mg/l)	Turbidity (NTU)
A	Secondary treatment, filtration, and disinfection	≤ 10	≤ 10	≤ 10	≤ 5
B	Secondary treatment, and disinfection	≤ 100	In accordance with Directive 91/271/EEC (Annex I, Table 1)	In accordance with Directive 91/271/EEC (Annex I, Table 1)	-
C	Secondary treatment, and disinfection	≤ 1 000			-
D	Secondary treatment, and disinfection	≤ 10 000			-

→ **Key questions:** Should we develop models that predict effluent E. coli concentrations? How much can we say about hygiene if we measure E. coli below detection? Or 800'000 / 100 mL?

→ **Problem:** We cannot directly monitor "hygiene" or pathogens

EU. (2020). Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse. In. http://data.europa.eu/eli/reg/2020/741/oj.

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What factors influence microbial safety in water reuse?

Treatment

[1] Type of input water
- Wastewater
- Greywater

[2] Scale of water input
- City
- Large building
- Single family
- Appliance

[3] Type of treatment
- Biological treatment
- Membrane filtration
- UV
- Free chlorine
- …

[4] Type of water use
- Irrigation
- Toilet flushing
- Washing machine
- Shower

[5] Acceptable pathogen concentrations depend on (a) exposure and (b) acceptable risk of infection (e.g., 10^{-4} or 10^{-2} per year) or acceptable disability-adjusted life years (DALYs)

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Quantifying required log removal target (LRT)

Risk of infection

Volume ingested

Target log removal

$$\mathrm{Pinf}_{\mathrm{annual}} = \text{Benchmark infection risk}$$

$$= S * \left(1 - \prod_{n_i}\left[1 - DR\left(V_i * 10^{(log_{10}(C) - LRT}\right)\right]\right)$$

Pathogen (susceptibility, dose/response and abundance in source)

Schoen, M.E., Ashbolt, N.J., Jahne, M.A. and Garland, J. (2017) Risk-based enteric pathogen reduction targets for non-potable and direct potable use of roof runoff, stormwater, and greywater. *Microbial Risk Analysis 5, 32-43.* *https://doi.org/10.1016/j.mran.2017.01.002*

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Diverse targets for different scales and types of reuse

Eva Reynaert

Scale: required log removal target (LRT) from QMRA by reuse application and source

Building, apartment complex (1000 people)

Group	Pathogen	Mixed greywater to irrigation	Toilet flushing(*)	Washing machine	Handwashing	Shower	Mixed greywater
Protozoa	Giarda	3.1	4.8	0.7	0.7	3.4	3
Protozoa	Crypto.	3.7	5.2	1.1	1.2	3.8	3.5
Bacteria	ETEC	1.4	2.9	0	0	1.5	1.1
Bacteria	Campyl.	3.8	5.3	1.3	1.3	3.9	3.6
Bacteria	Salmo.	1.1	2.6	0	0	1.3	0.9
Viruses	Rotav.	6.3	7.9	3.8	3.8	6.5	6.1
Viruses	Norov.	3.9	5.6	1.6	1.6	4.2	3.9

Household (5 people)

Group	Pathogen	Mixed greywater to irrigation	Toilet flushing(*)	Washing machine	Handwashing	Shower	Mixed greywater
Protozoa	Giarda	0	0	0	0	0	0
Protozoa	Crypto.	0	0	0	0	0	0
Bacteria	ETEC	0	0	0	0	0	0
Bacteria	Campyl.	0	0	0	0	0	0
Bacteria	Salmo.	0	0	0	0	0	0
Viruses	Rotav.	0	0	0	0	0	0
Viruses	Norov.	4.4	6.1	1.9	2.1	4.5	4.4

Reuse application and source

(*) "Toilet flushing" is water from surface cleaning in the Autarky toilet while urine and faeces are collected separately (www.autarky.ch)

Reynaert et al. (2024) In preparation

Take home messages

- State variables in typical wastewater treatment modeling (e.g., activated sludge modeling, computational fluid dynamics, …) are directly relevant to answer questions

- “Hygiene” cannot be a state variable and direct modeling of “hygiene” is not possible

- Mathematical modeling is a necessary tool to predict hygiene – but only by a combination of different modeling approaches

Pathogen loads in the wastewater

Removal and inactivation of different viruses, bacteria, and protozoa in a treatment train

Uncertainty

Exposure depending on type of reuse

Monitoring requirements

Failure modes and effect analysis

Benefits of online sensors

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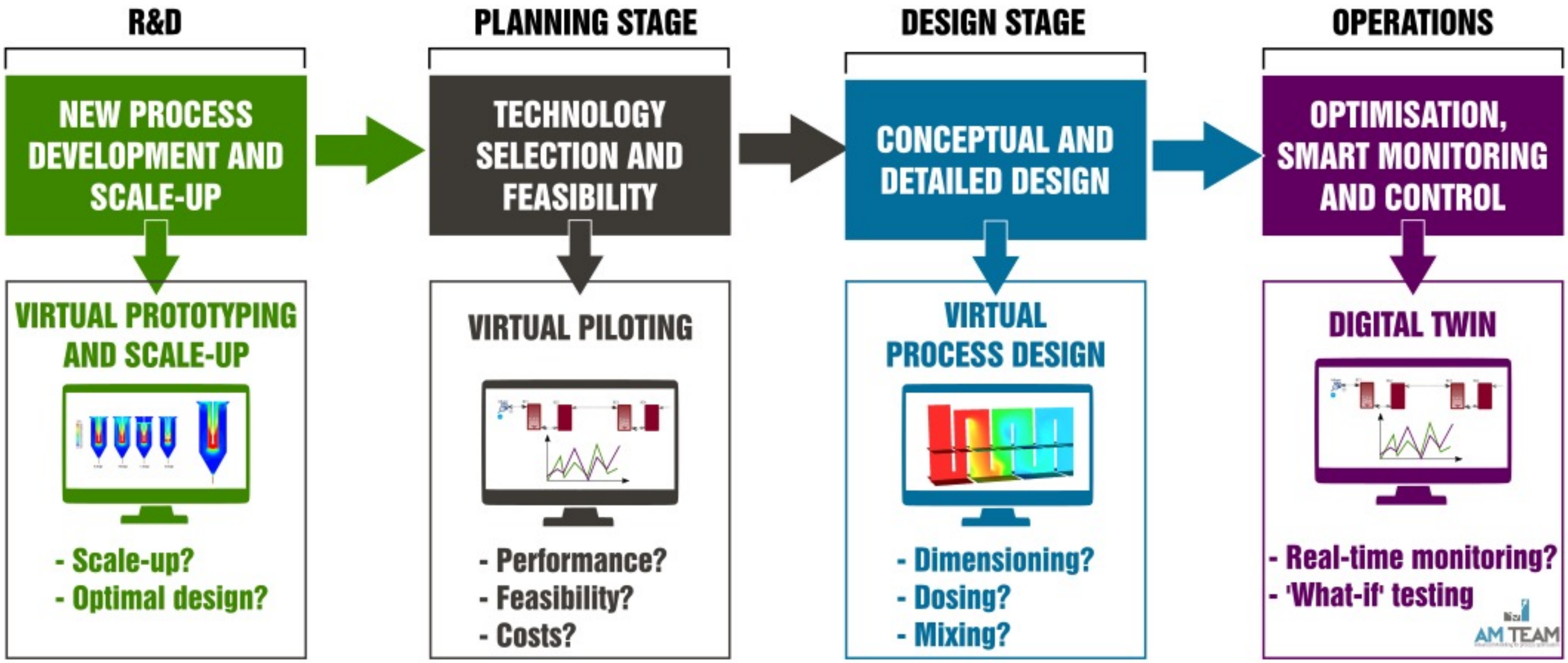
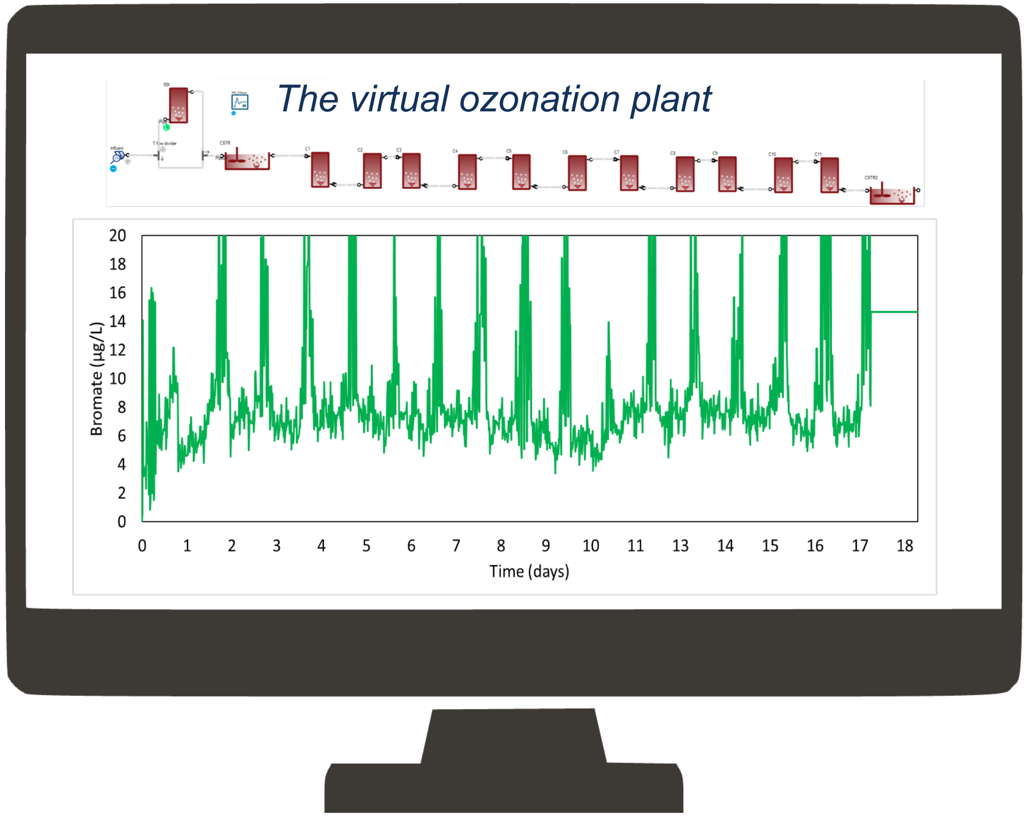
Process modelling for water reuse

Process models span the whole technology lifecycle



Introduction to the model

- Ozonation and AOP model (UV/H_2O_2)
  - Applied to > 25 reactors worldwide (USA, Hong Kong, Europe)

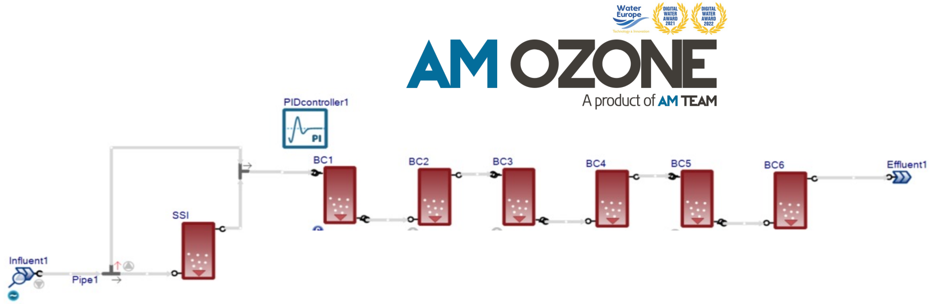


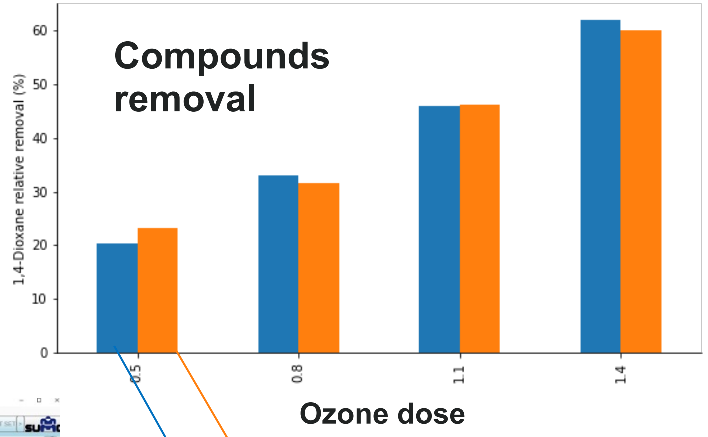
Front end

- (Real-time) prediction of
  - Ozone
  - Hydroxyl radicals
  - Bromate
  - >100 Micropollutants or CECs
  - Taste and odor compounds
  - …

Example 1: Virtual piloting

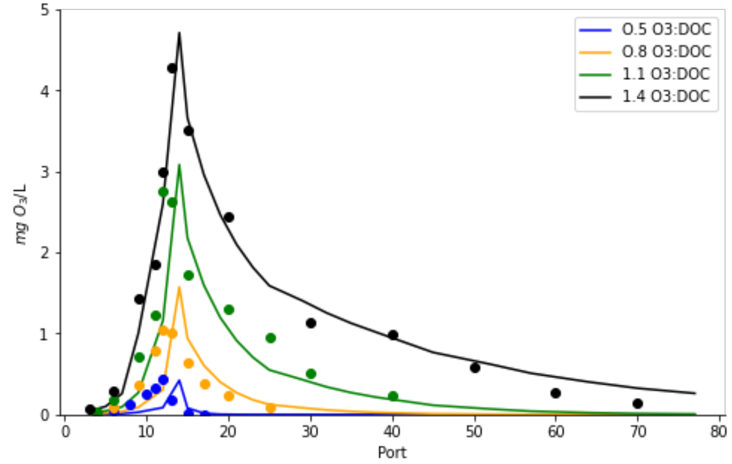
WATER REUSE
the international water association

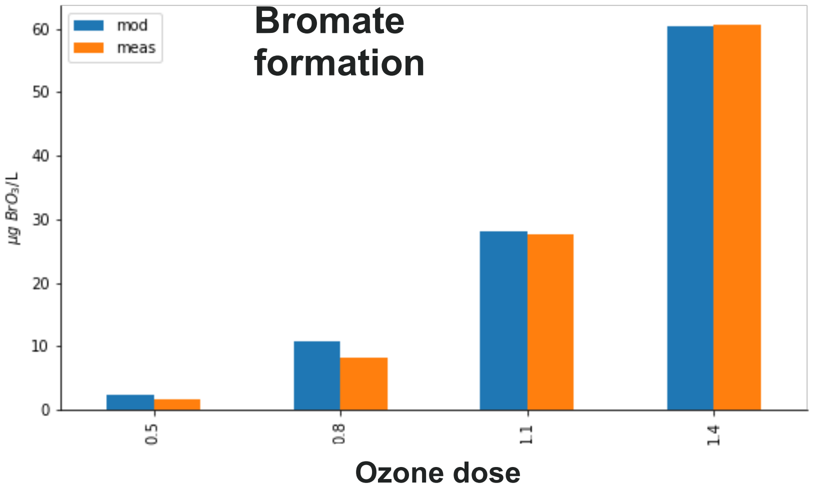




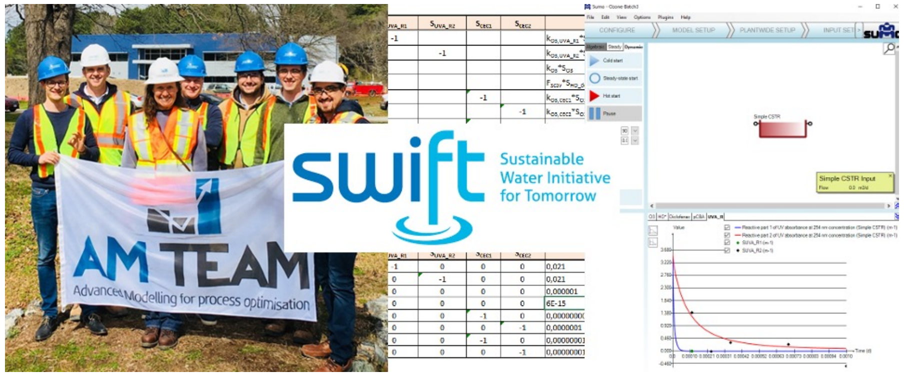
Measurement

AMOZONE

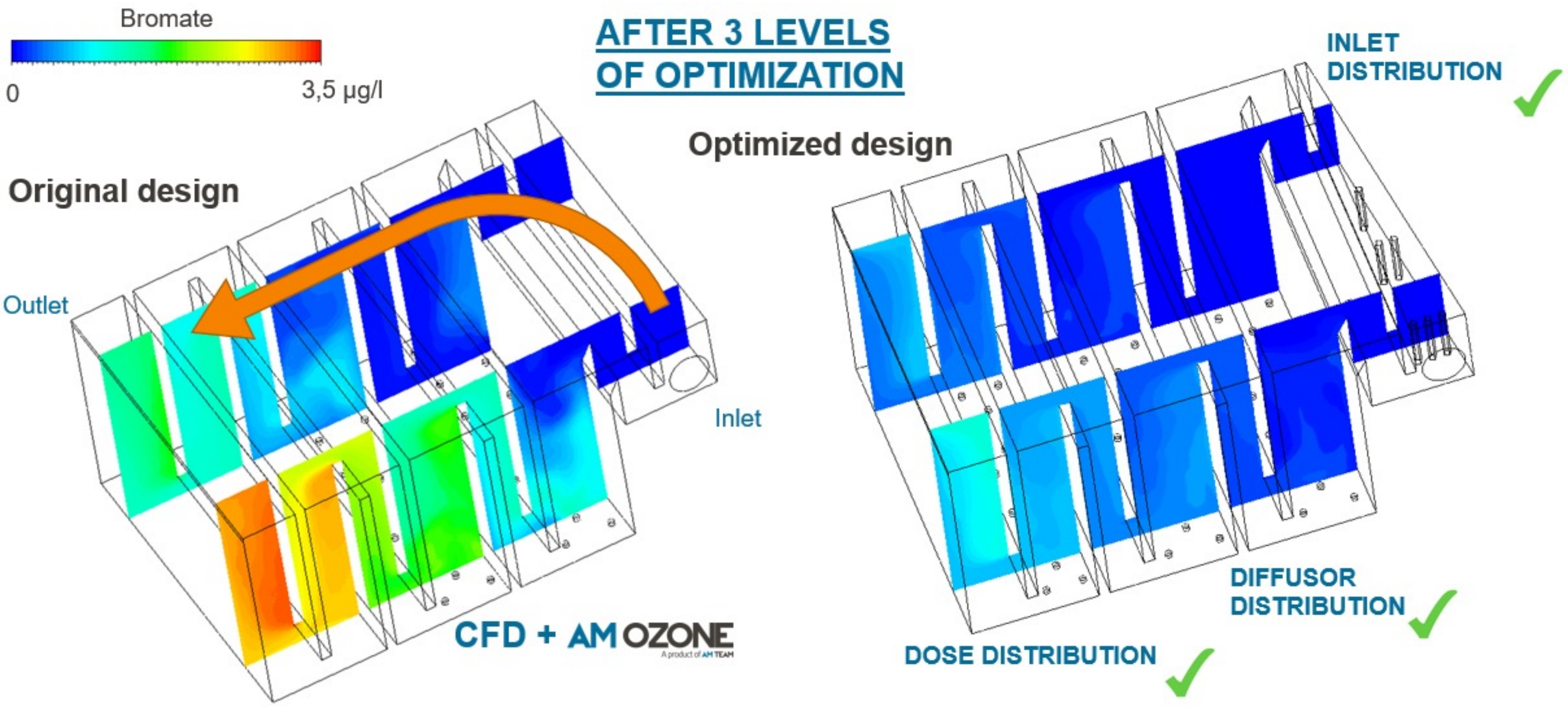




HRSD
Cleaning wastewater every day for a better Bay.

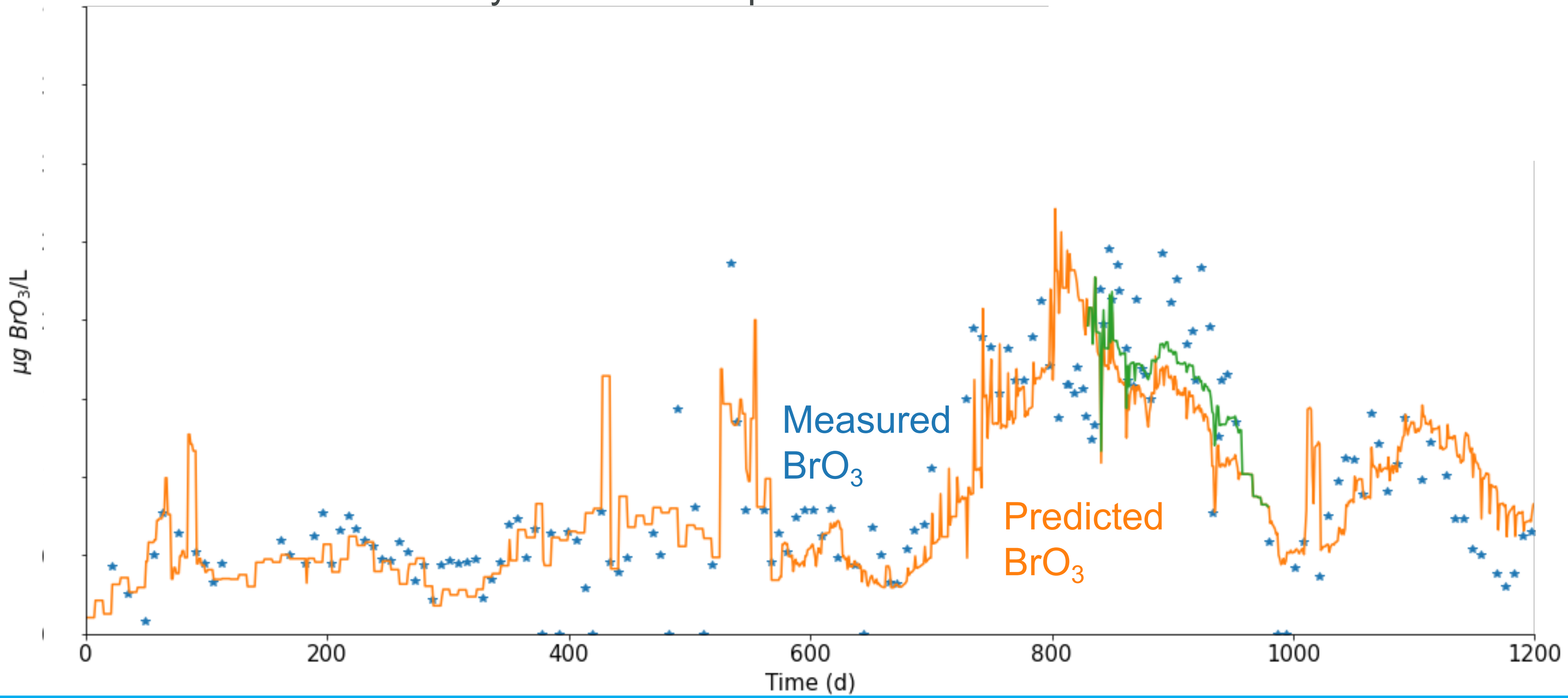


Example 2: Design optimization



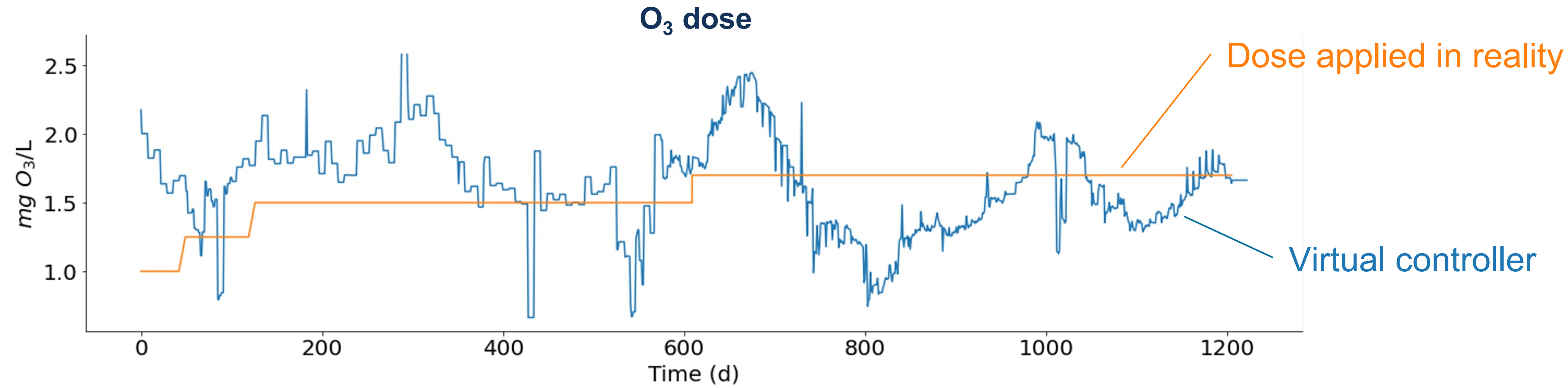
Example 3: Digital Twin for O_3/UV/peroxide

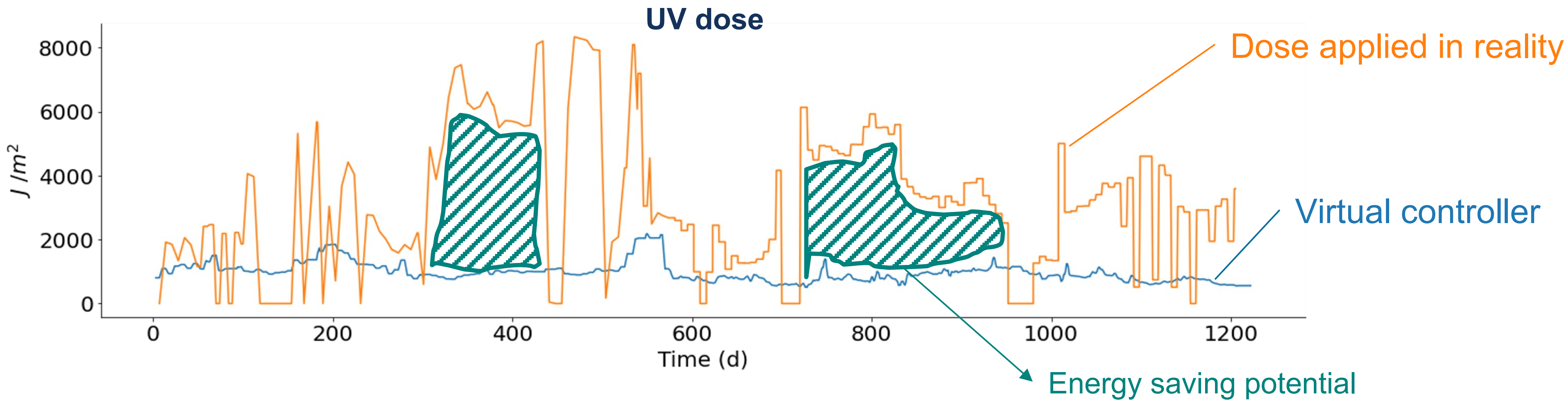
- Real time prediction of byproducts (bromate)
- What if scenario – analysis for smart operation



Example 3: digital twin for O3/UV/peroxide

- What would be the impact on OpEx and CO_2-footprint if we would have changed the dose?





AGENDA AND HOUSEKEEPING

Introduction to specialist groups
Elena Torfs (ULaval, CA, chair modelling and integrated assessment)
Josef Lahnsteiner (Wabag, AT, chair water reuse)

Water reuse
Josef Lahnsteiner (Wabag, AT)

Process models
Giacomo Bellandi (AM-Team, BE)

Microbial risk assessment
Eberhard Morgenroth (EAWAG, CH)

Impact assessment models
Luca Penserini (PoliMi, IT)

Q&A Session Moderator: *Mariane Schneider (UGent, BE)*

- This session is being recorded;
- Please do not use the chat function.
- Please put any questions and comments you may have in the Q&A and we will do our best to answer them during the session (in writing or orally).
- Microphones and cameras have been disabled due to the large number of attendees

WATER REUSE

Overview of available impact models for wastewater reuse in agriculture

LUCA PENSERINI, PhD Student
safeWATER group @Politecnico di Milano
Department of Civil and Environmental Engineering (DICA)

Background: impacts of the wastewater reuse

- Indirect reuse is *de facto* implemented without evaluating impacts
- Evaluation of positive impacts associated with direct reuse
- Presence of negative impacts with long-term effects for both direct and indirect reuse

Positive impacts

- Water recovery
- Nutrients recovery

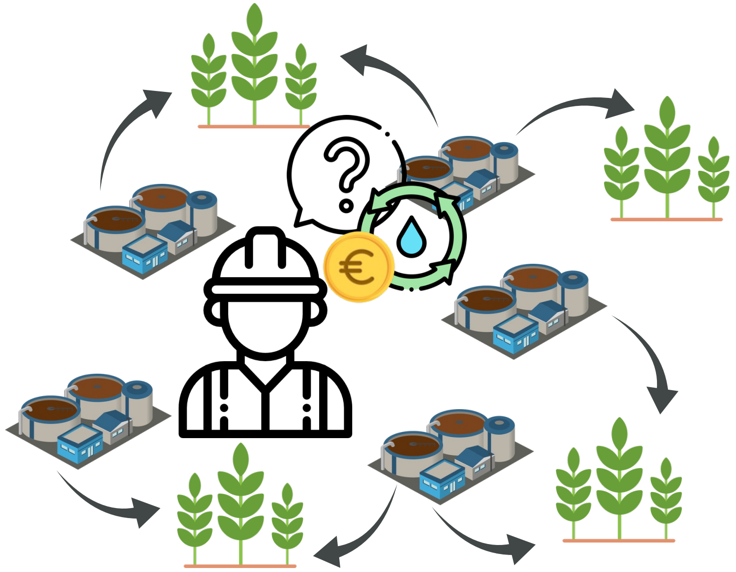
Negative impacts

- Salinization of soil and crops
- Cross-contamination
- Environmental risk
- Human health risk

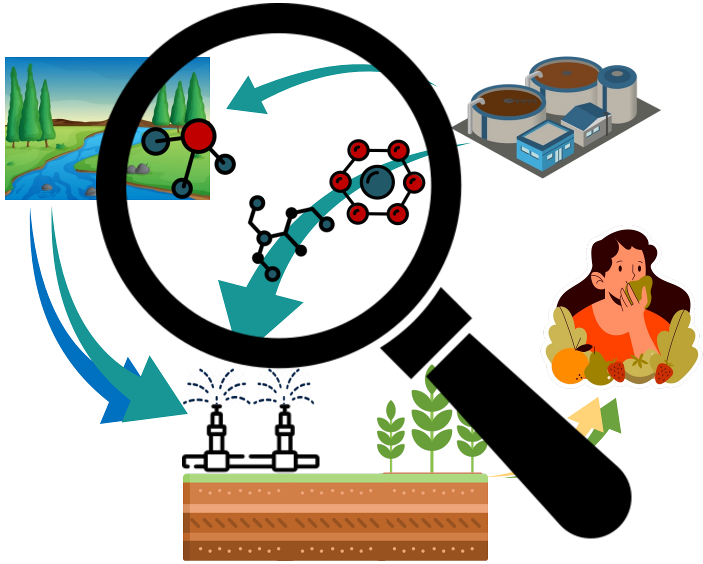
Key questions:

- Do we have models to assess all the impacts of reuse?
- How can they be integrated to support the decision-making process…

…to determine in which WWTPs implement reuse



…to identify which compartments and contaminants need more monitoring efforts



Key questions:

- Do we have models to assess all the impacts of reuse?
- How can they be integrated to support the decision-making process…

…to determine in which WWTPs implement reuse

…to identify which compartments and contaminants need more monitoring efforts

Available models for impacts assessment

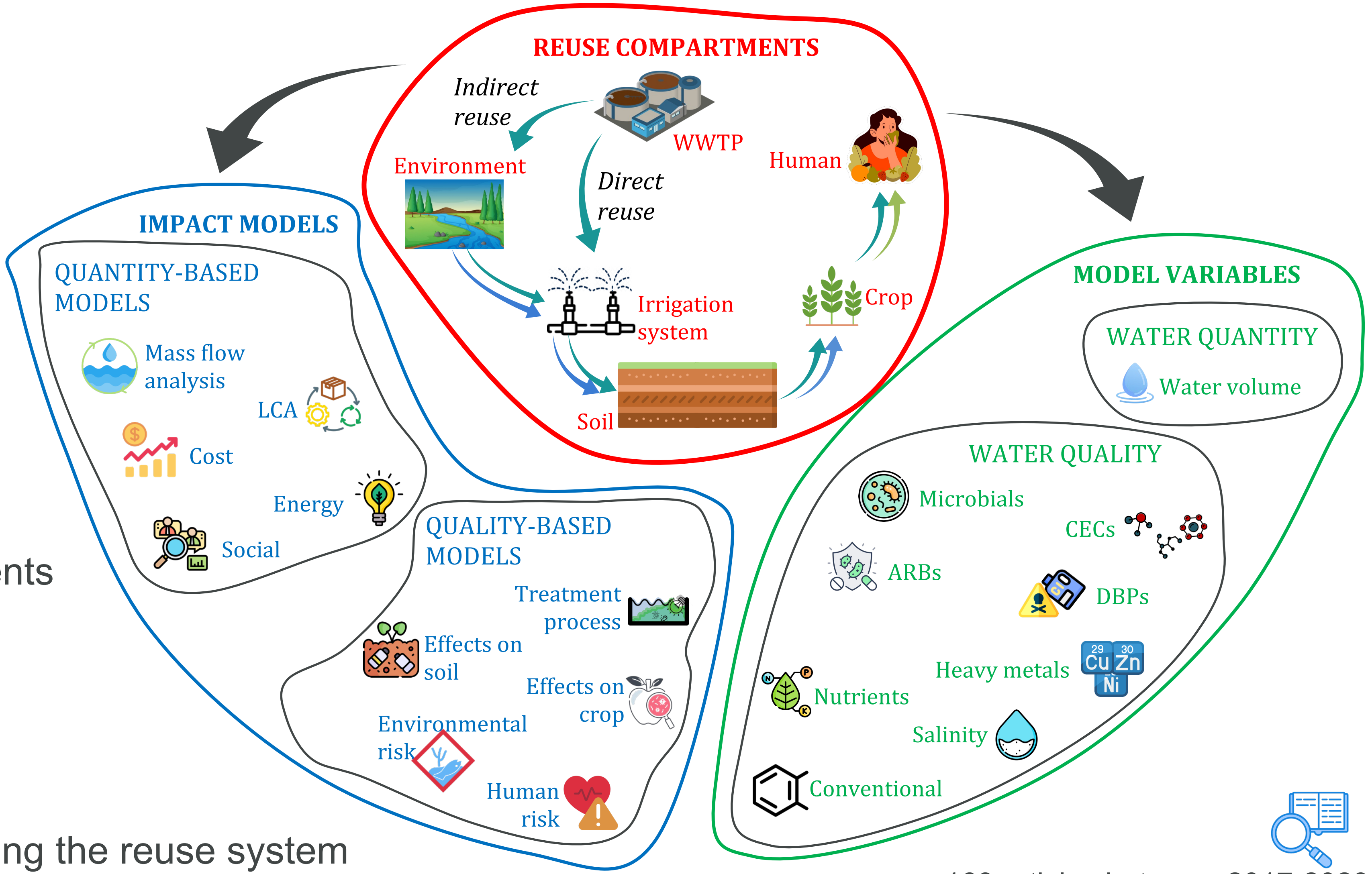
Quantity-based models:

- Consider water volume
- Used to model big-scale systems

Quality-based models:

- Consider contaminants content
- Used to model specific compartments

Not always well integrated for modelling the reuse system



163 articles between 2017-2023

Key questions:

- Do we have models to assess all the impacts of reuse?
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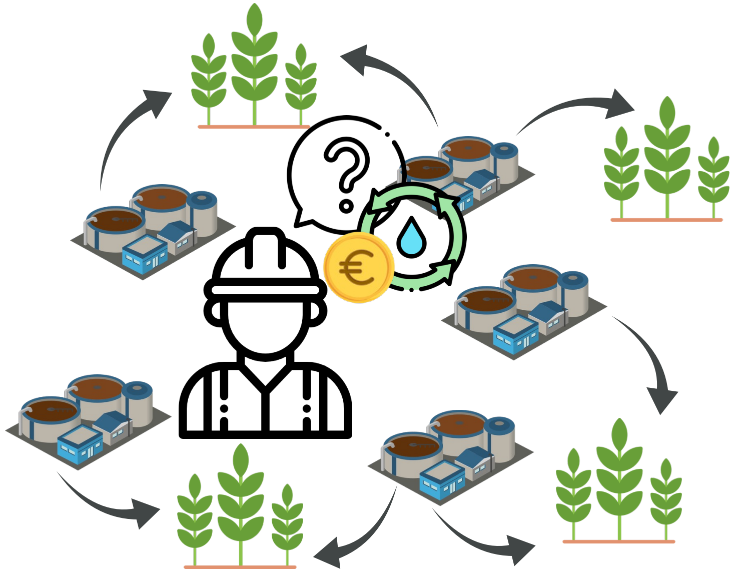
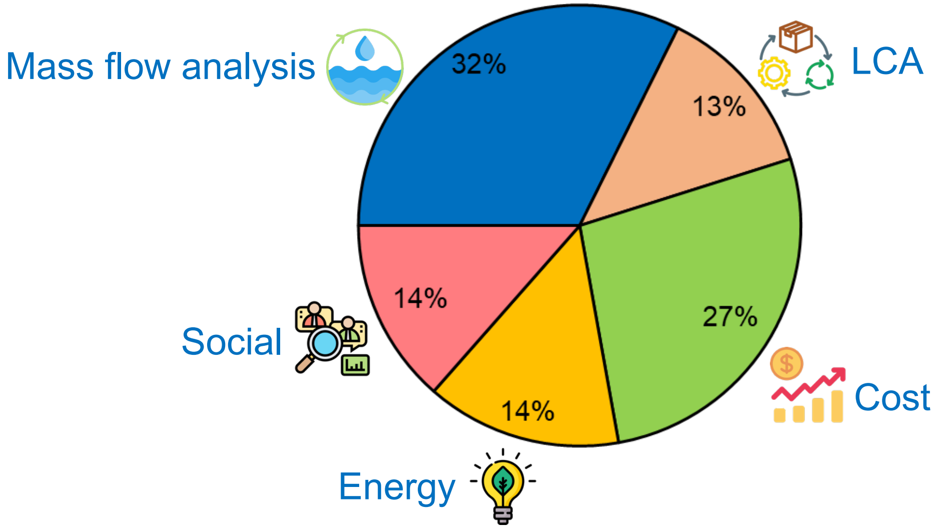
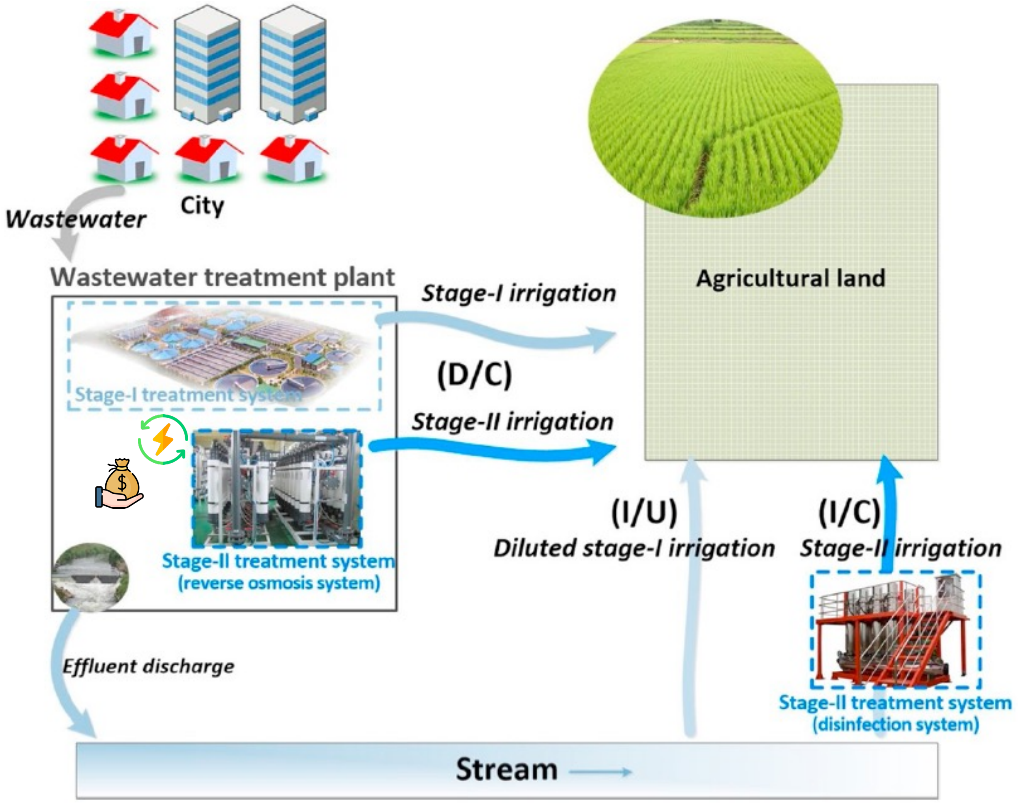


…to identify which compartments and contaminants need more monitoring efforts

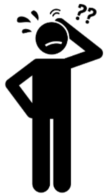
Where to implement reuse: state of the art





- Good integration between quantity-based models
- Optimization of water volumes allocation in a system

- Quality aspect is often overlooked



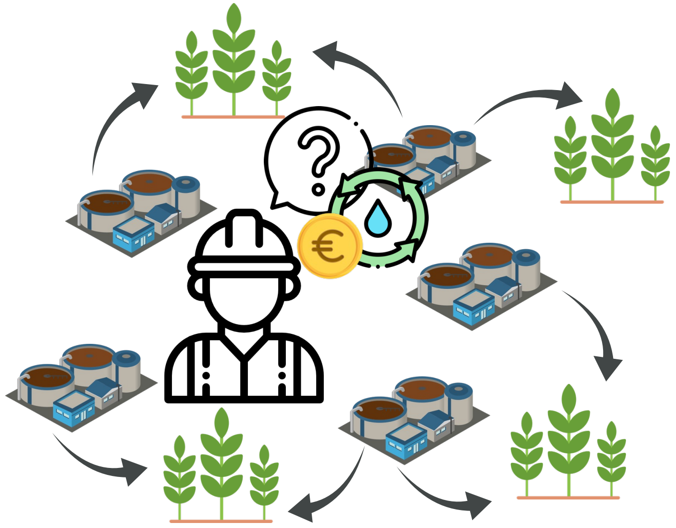
Is it important to consider water quality?

10.1016/j.agwat.2019.105983

Integration of quantity and quality aspects

WATER REUSE

Development of a techno-economic model



INPUTS

WWTP's effluent parameters

- Flowrate
- Total nitrogen (N)
- Total phosphorus (P)
- Electrical conductivity (EC)

Territory parameters

- Type of crops
- Crops' water and nutrients monthly requirements
- Crops' sensitivity to salinity
- Effective rainfall

TECHNO-ECONOMIC MODEL

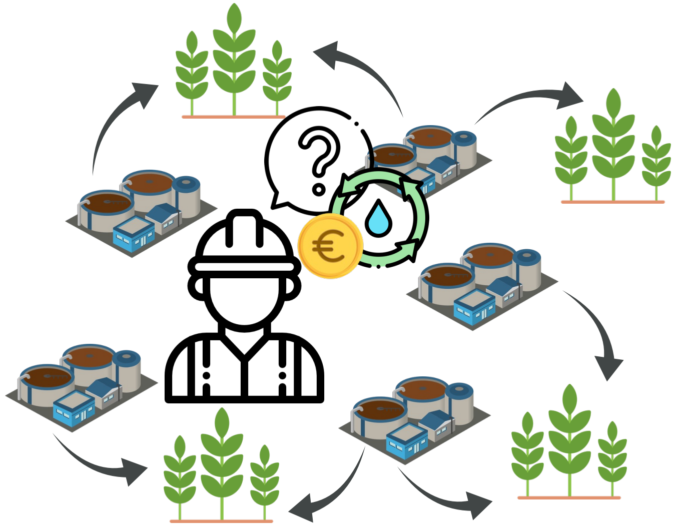
OUTPUTS

Determination of:

- Primary freshwater savings
- Mineral fertilizers savings
- Avoided GHG emissions
- Crop yield loss due to salinization

10.1016/j.scitotenv.2023.169862

Integration of quantity and quality aspects



Data collected from **95 WWTPs** distributed across northern Italy

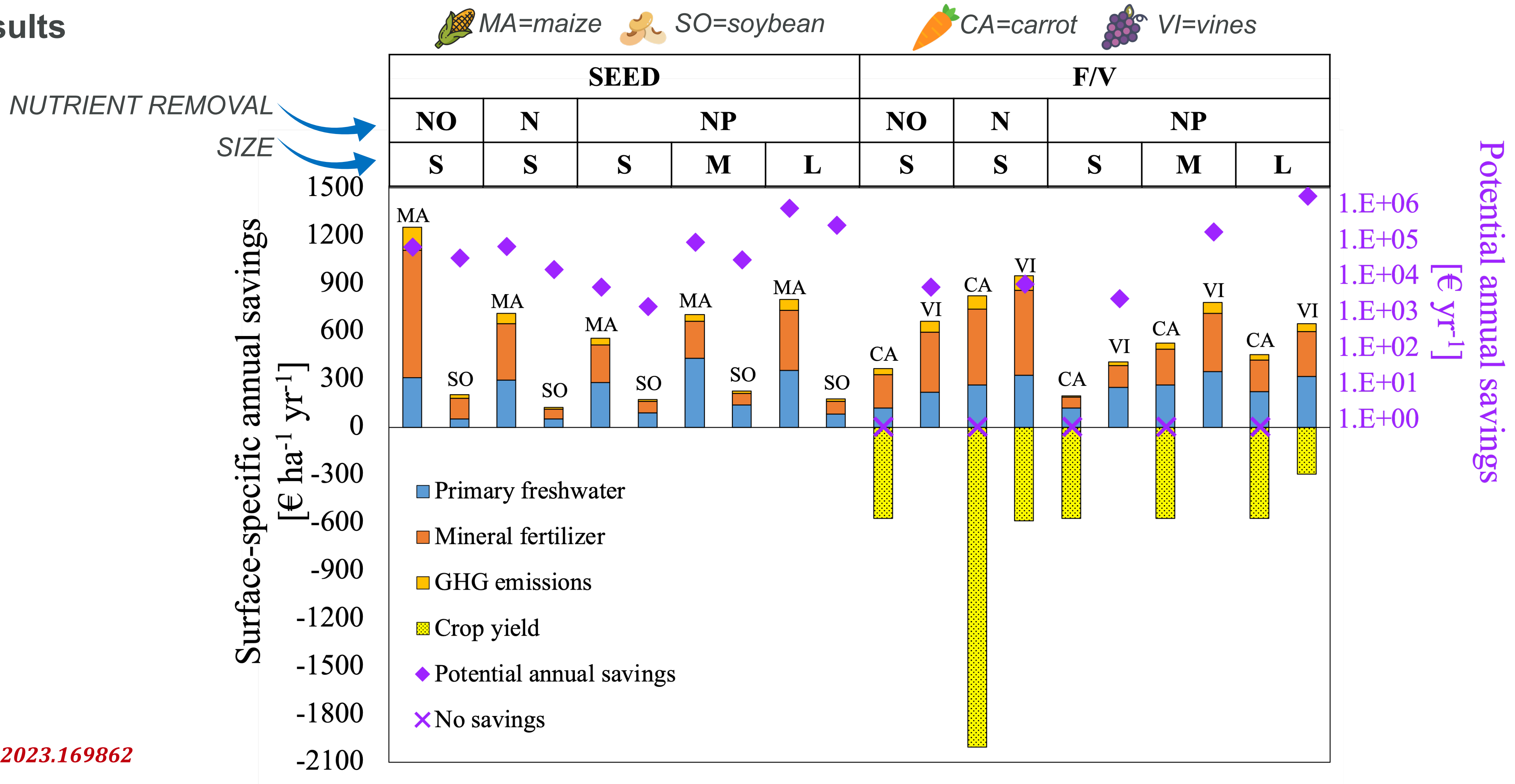
WWTPs classification

- Size
  - S (2,000 < P.E. < 10,000)
  - M (10,000 < P.E. < 70,000)
  - L (70,000 < P.E.)
- Nutrient removal
  - NO (no nutrient removal)
  - N (N removal)
  - NP (P removal)
- Crops
  - SEED (maize or soybean)
  - F/V (vines and carrots)

10.1016/j.scitotenv.2023.169862

Integration of quantity and quality aspects

Economic results



10.1016/j.scitotenv.2023.169862

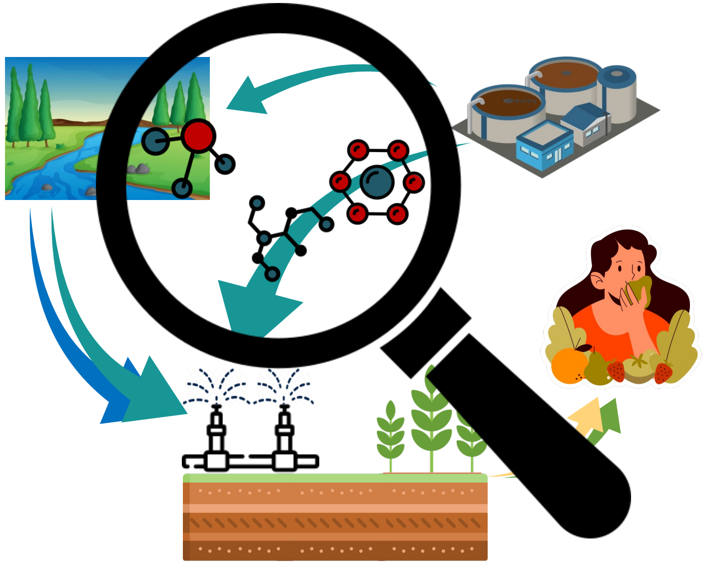
Key questions:

▶ Do we have models to assess all the impacts of reuse?

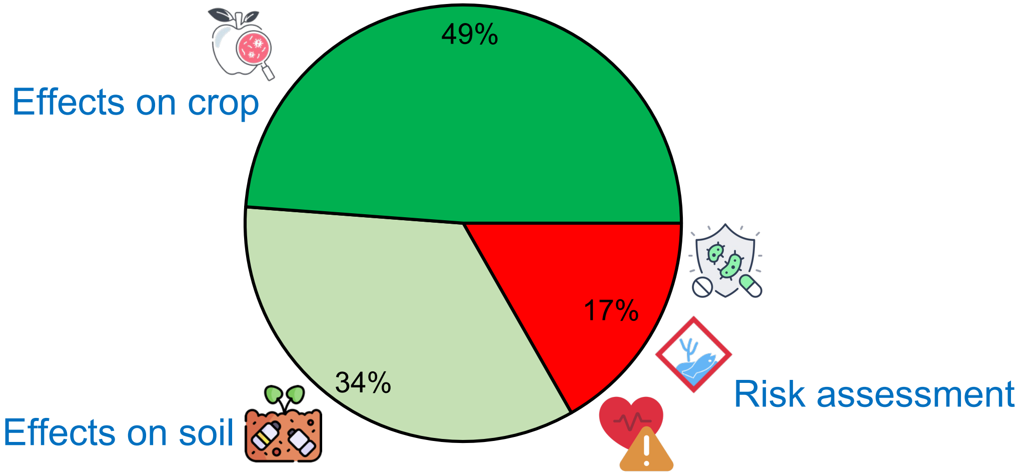
▶ How can they be integrated to support the decision-making process…

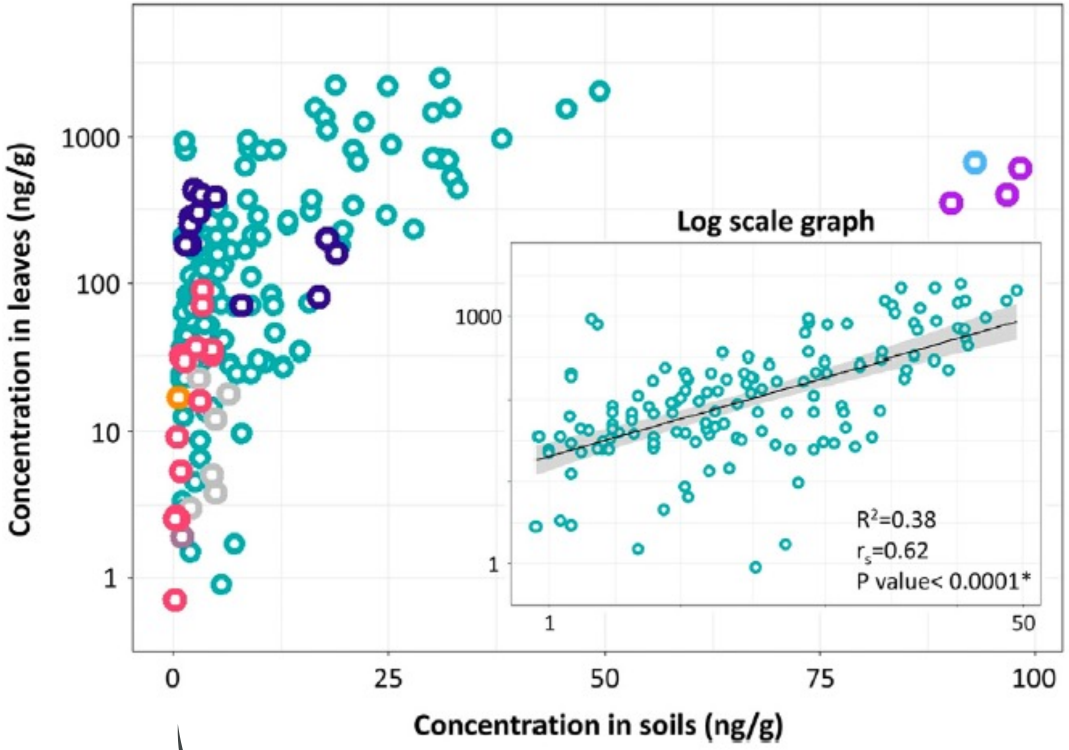
…to determine in which WWTPs implement reuse

…to identify which compartments and contaminants need more monitoring efforts



Where to focus monitoring efforts: state of the art



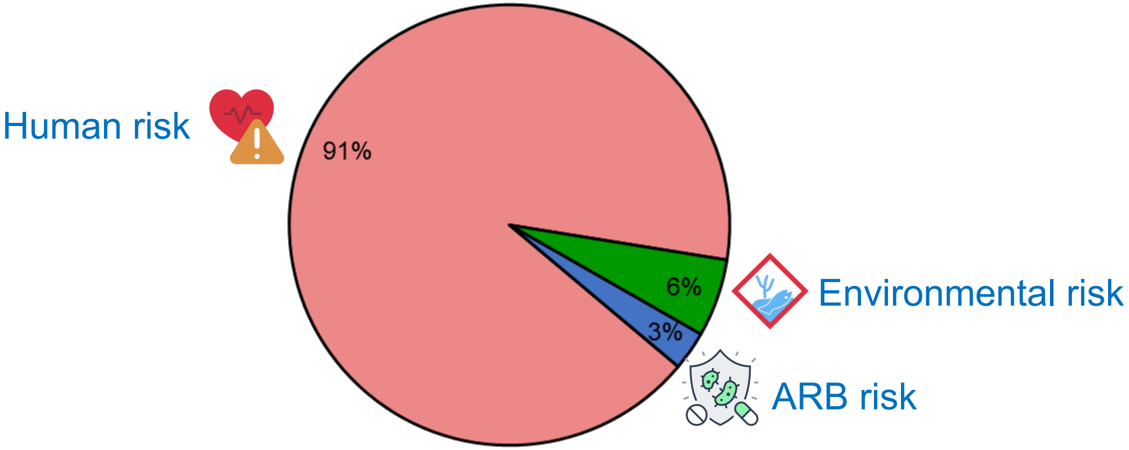


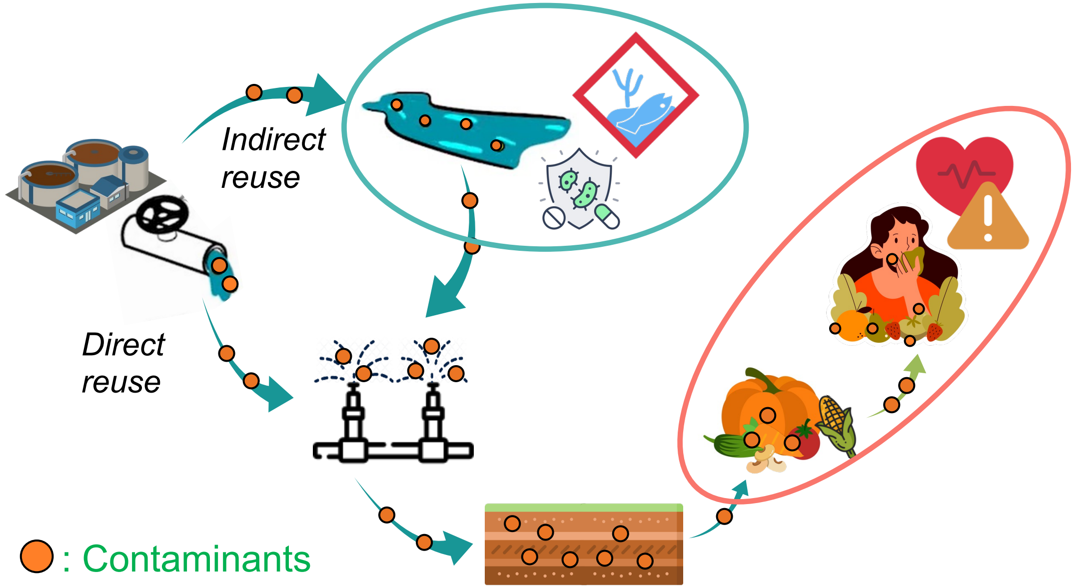
- Effects on soil and crops are well studied
- Analysis of contaminants fate in soil and crops
- Minor attention given to risk assessment procedures

$$\text{Risk} = \frac{\textit{Concentration}}{\textit{Toxicity Level}}$$

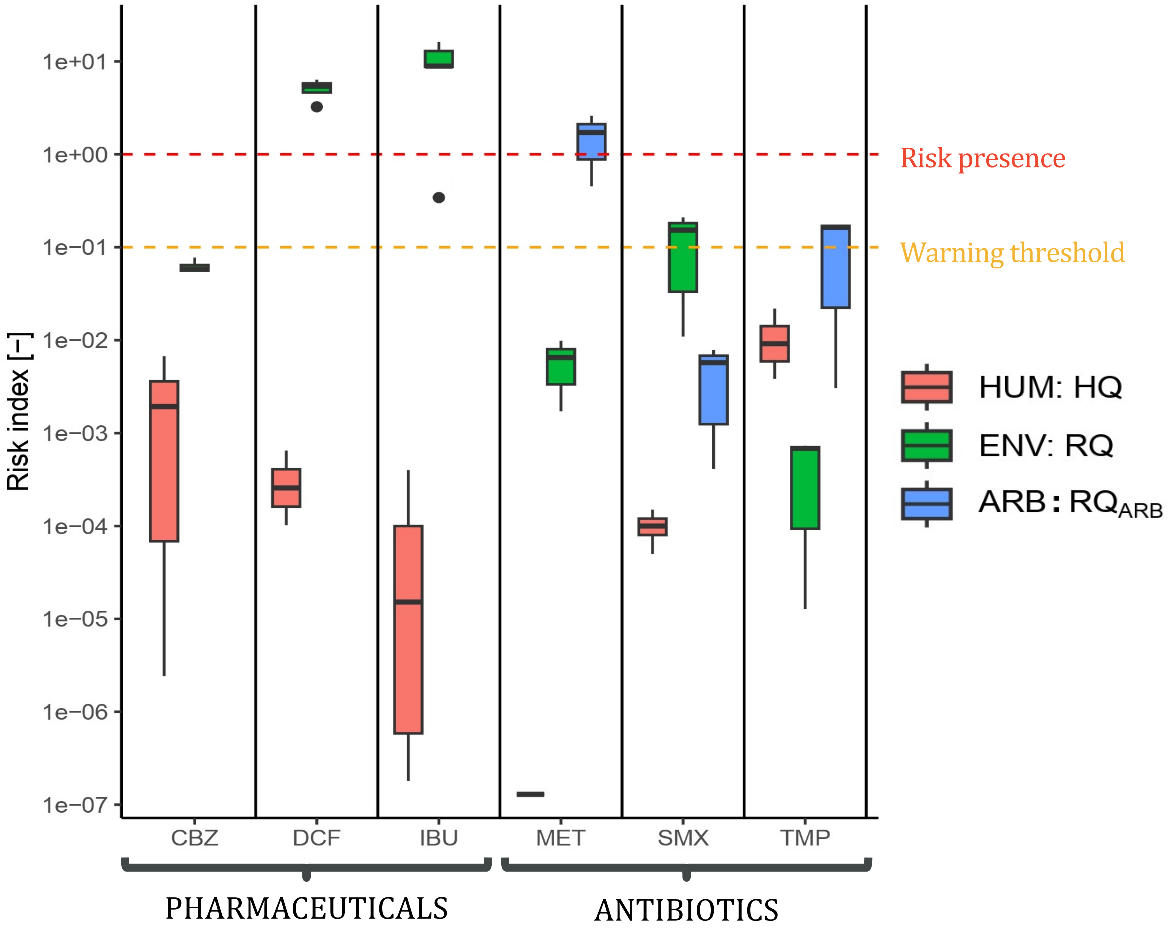
10.1016/j.scitotenv.2022.153574

Integration of risk assessment procedures



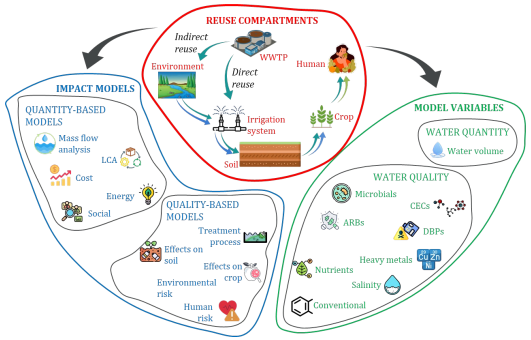


Focus on studies evaluating the chemical risk for human health

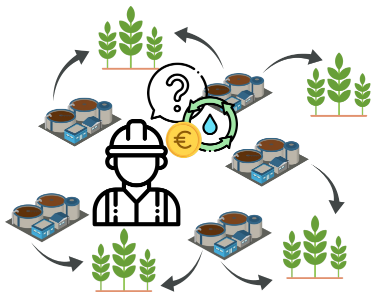


CBZ=Carbamazepine, DCF=Diclofenac, IBU=Ibuprofen, MET=Metronidazole, SMX=Sulfamethoxazole, TMP=Trimethoprim

Take home messages:



- ➢ Different models are available to be integrated for **multiple impacts evaluation**



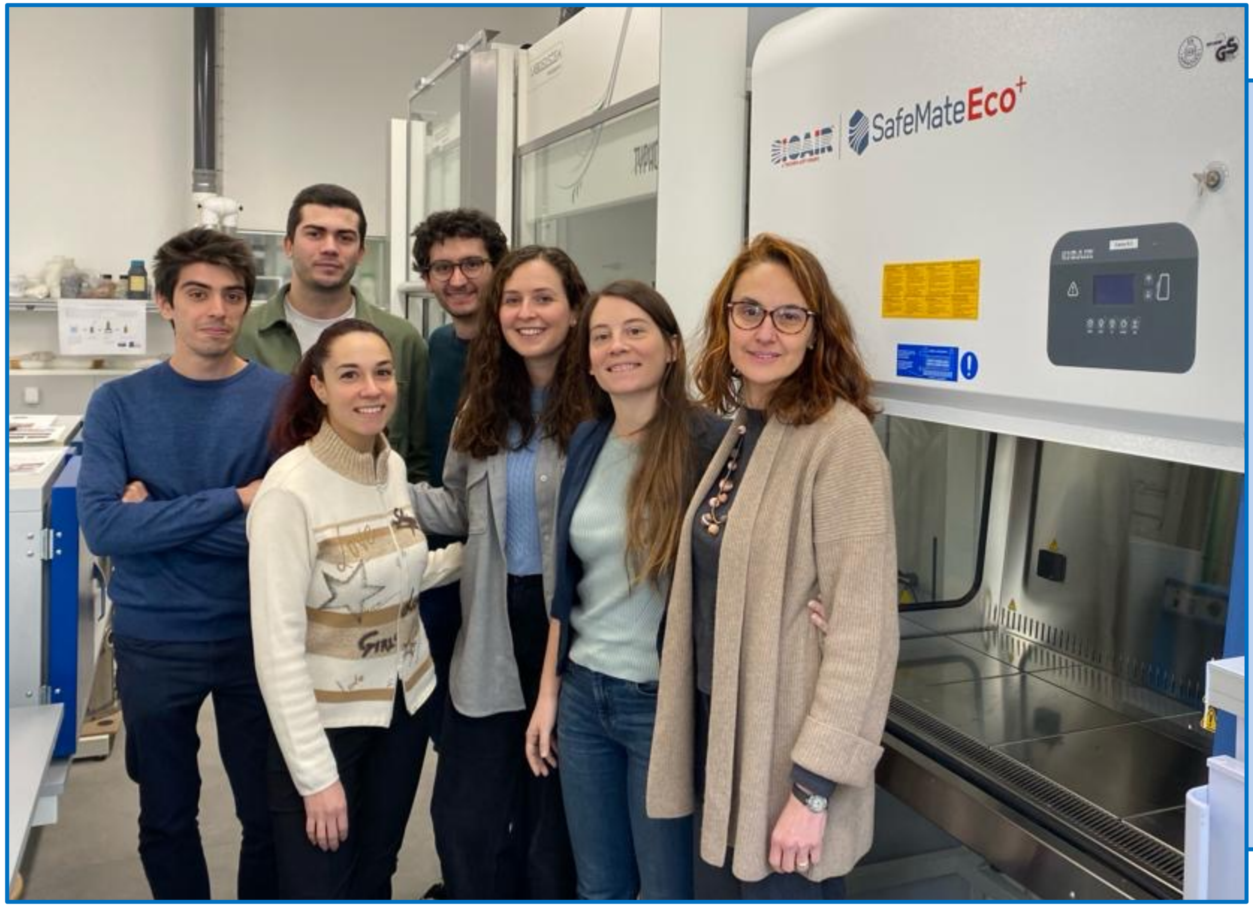
- ➢ Water **quality** does matter, especially when related to crops requirements

- ➢ **Risk assessment** procedures should be integrated in a **ONE-Health perspective**

THANK YOU FOR YOUR ATTENTION

IWA the international water association WATER REUSE

safeWATER group @Politecnico di Milano



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