Addressing water management challenges with **c**ombined **N**atural & **E**ngineered **S**ystems

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AquaNES project coordination

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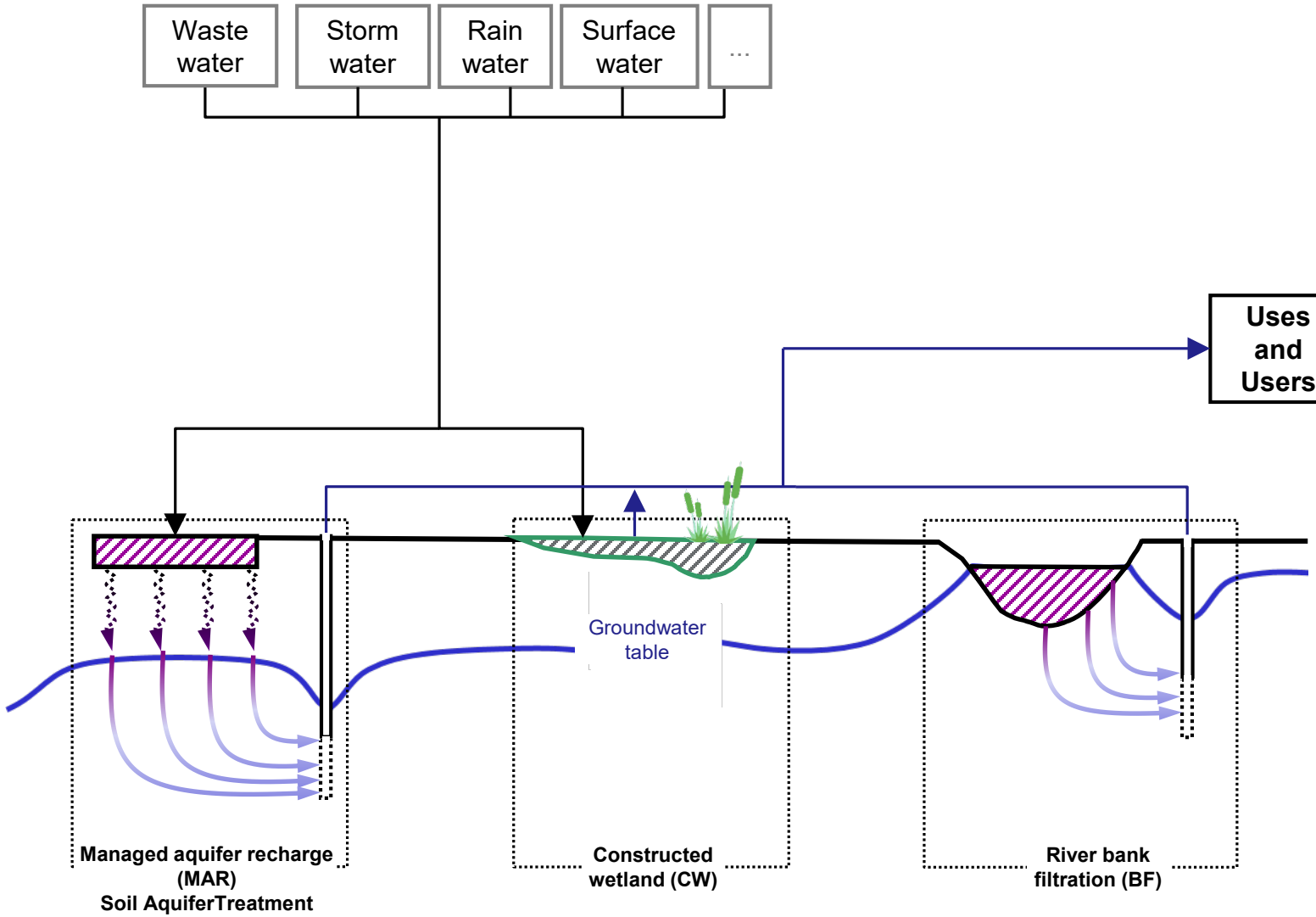
www.aquanes.eu

Outline

- Challenges
  - Status and trends in Europe
    - Water quantity and quality
    - Legal compliance and implementation gaps
    - Drinking water
    - Wastewater
    - Micropollutants
    - Water Reuse
- How has AquaNES adressed these
  - Project scope and approach
  - Sites and technologies

Water treatment by nature-based processes



Natural component

Industrial uses

Drinking water

Bathing water

Water reuse

Agricultural irrigation

Discharge to the environment

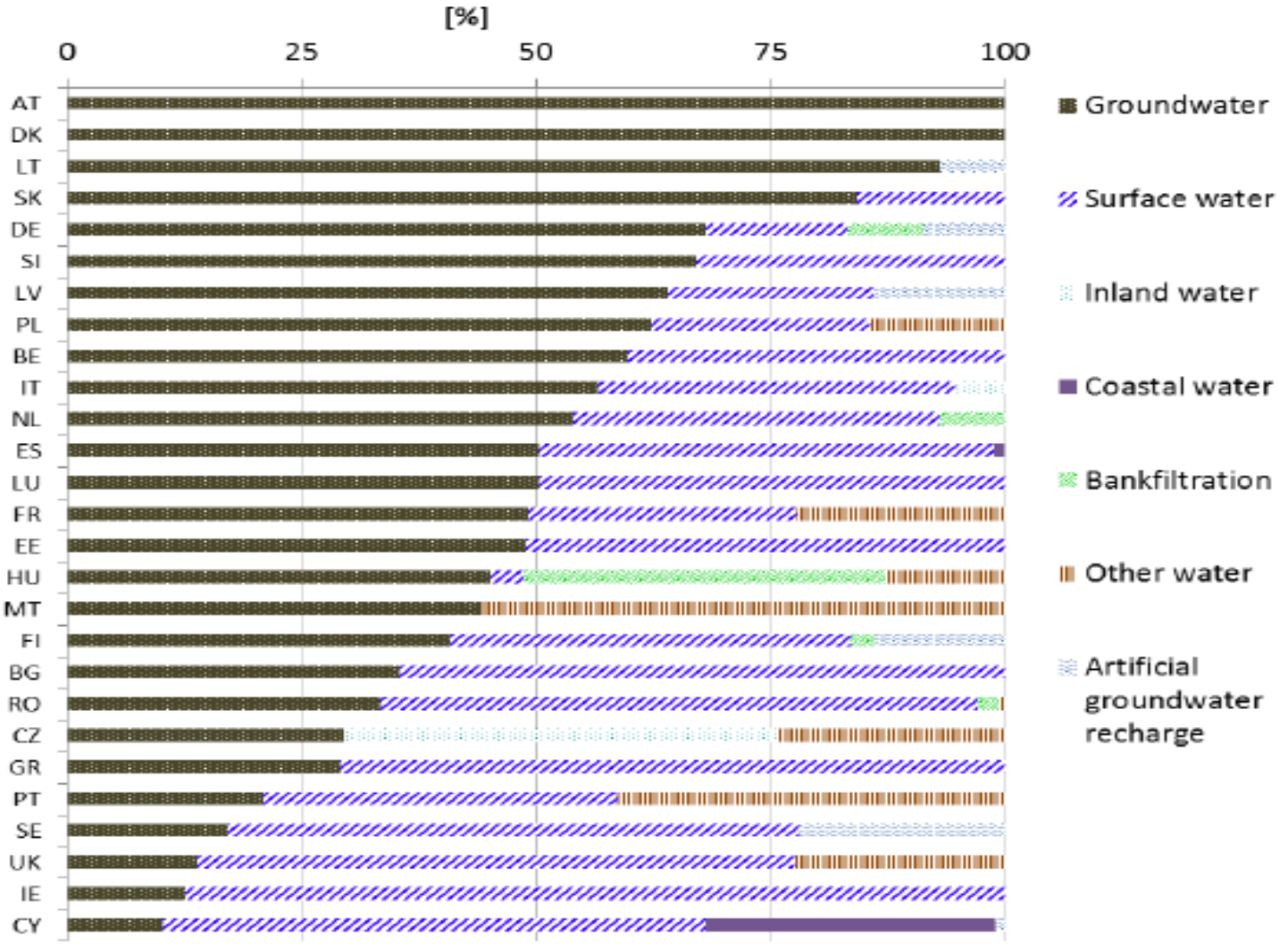
Challenges and trends




– Source water availability
– Source water quality deterioration

– Legal requirements
– Ecologic aspects and ambition
– Economic constraints

Drinking Water by source in EU



Upgrading existing bank filtration sites?

- Germany
- The Netherlands
- Hungary
- Finland
- Romania

Drinking Water Treatment technologies (Survey among EurEau Members)

49% 46% 3% **2%**

of total drinking water production

Treatment scheme	Raw water source: Groundwater	Surface water	Surface water + artificial recharge	Riverbank filtration
No treatment	-	-	surface water + AR[3] without treatment	no post treatment
Conventional treatment	aeration and/or RSF[1]	CSF[2]	surface water + AR[3] with treatment: aeration and/or CSF	post treatment: aeration and/or RSF[1]
Advanced treatment	carbon filtration, AOP[4], membranes, desalination, etc.	carbon filtration, AOP[4], membranes, desalination, etc.	surface water + AR[3] with treatment: advanced treatment like carbon filtration, AOP[4], membranes, desalination, etc.	post treatment: carbon filtration, AOP[4], membranes, desalination, etc.
Conventional + advanced treatment	aeration and/or RSF[1] + advanced treatment	CSF[2] + advanced treatment	surface water + AR[3] with treatment: aeration and/or CSF[2] + advanced treatment	post treatment: aeration and/or RSF[1] + advanced treatment

59%

41%

[1]Rapid Sand Filtration; [2]Coagulation/Sedimentation/Filtration; [3]Artificial Recharge; [4]Advanced oxidation Processes

Van der Hoek et al., 2014
Study covering approx. 58% of European population

Drinking Water Treatment technologies
Challenges (Emerging compounds)

- **59% of the total drinking water production is not treated or treated with conventional treatment**
  - 50% removal rates of pharmaceuticals with conventional treatment (coagulation/filtration/chlorination)
  - 90% removal with advanced treatments (ozonation, advanced oxidation, activated carbon and membrane processes)

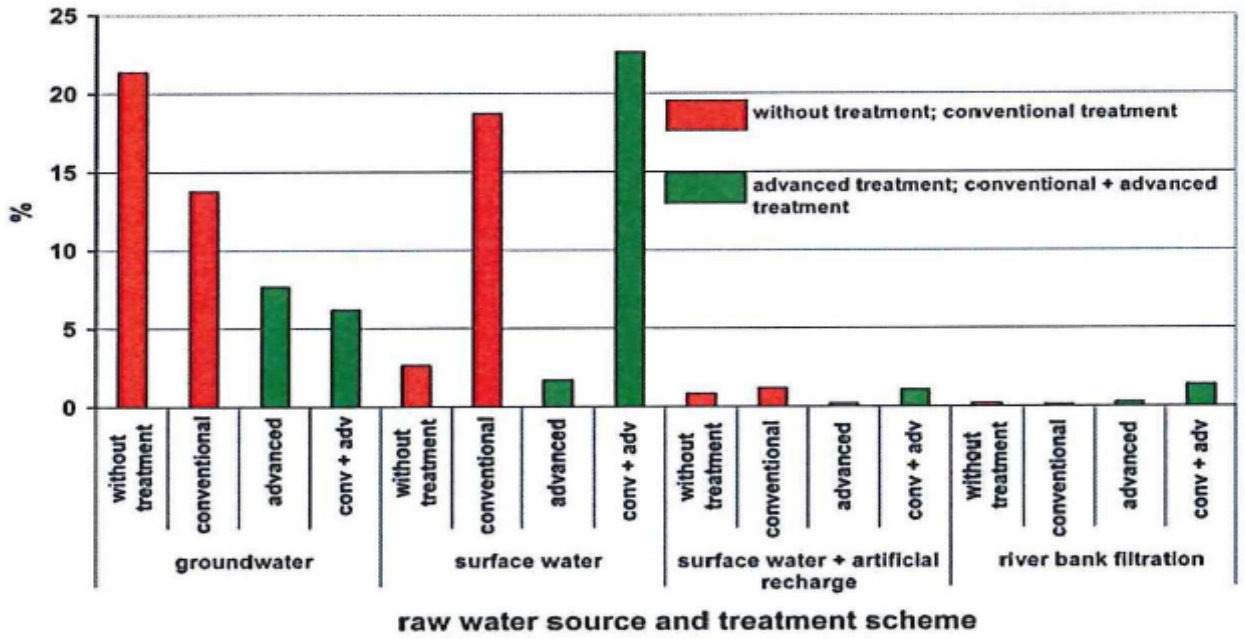
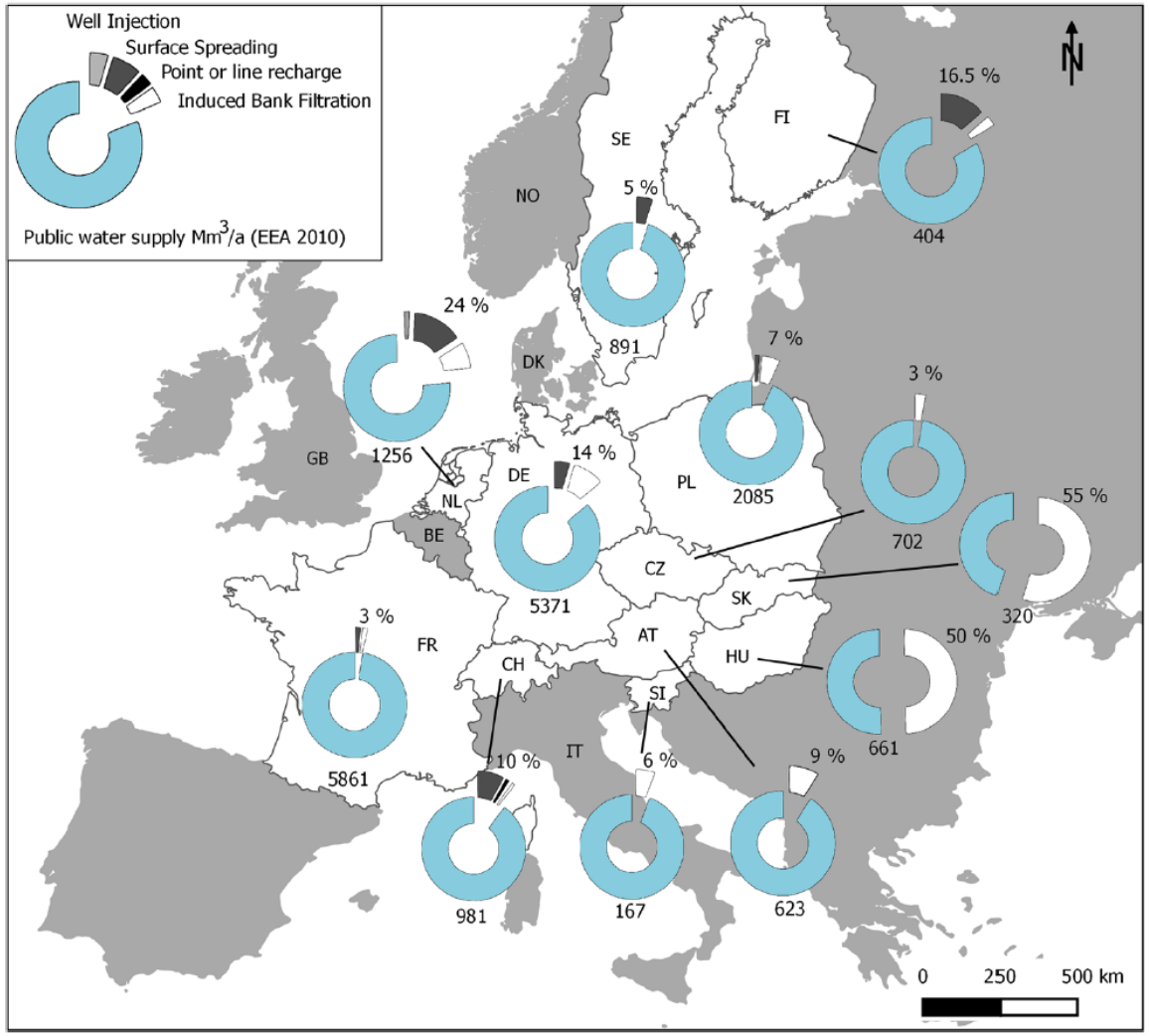


Figure 2 | Raw water sources and treatment schemes.

Van der Hoek et al., 2014

Share of BF/MAR in public water supply

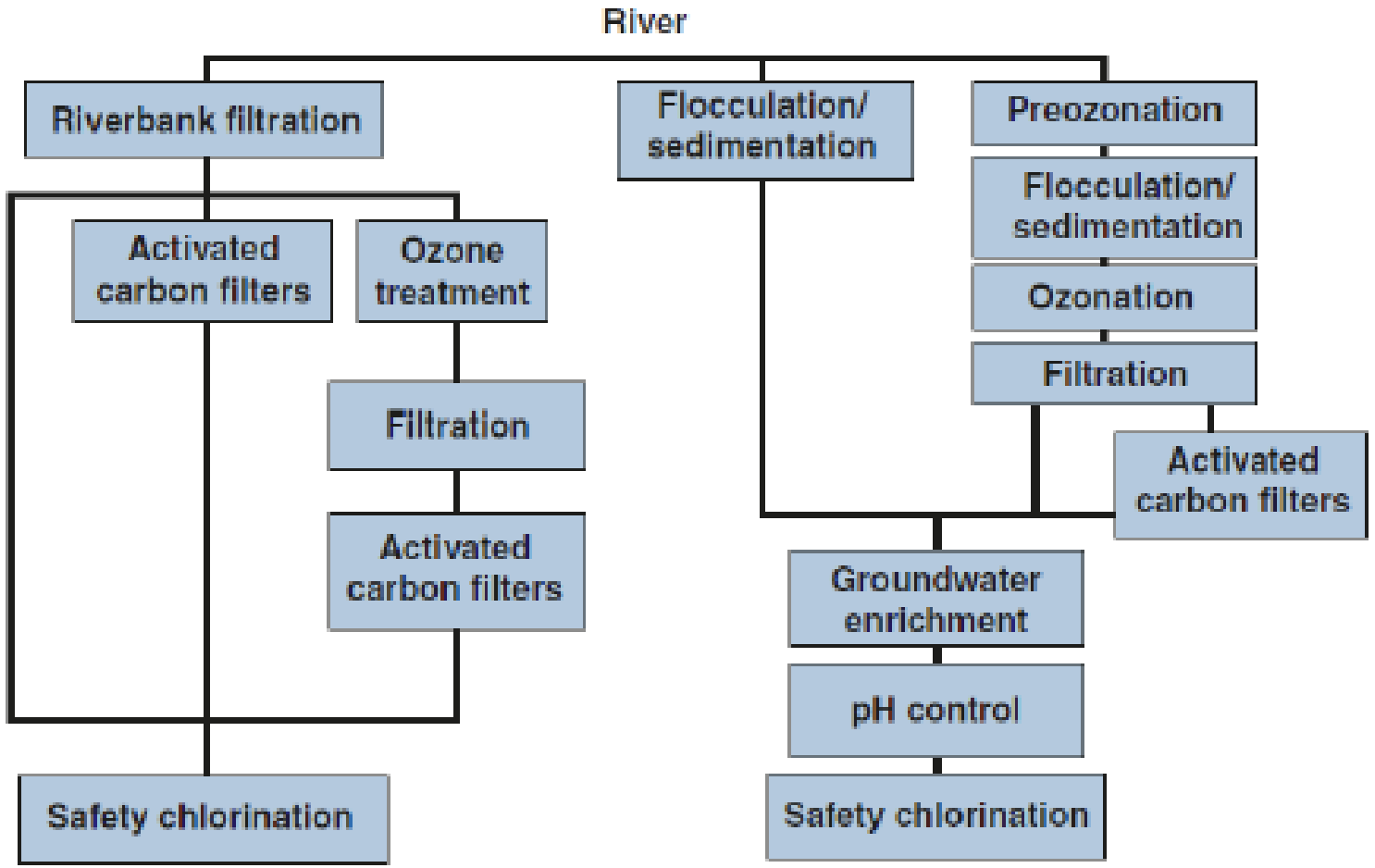


Sprenger et al., 2017

Country	Number of BF Sites	Overall Operational Capacity (m3/y)
Germany	49	544,564,073
Hungary	5	391,172,000
Slovakia	5	185,055,000
Netherlands	40	153,750,999
Poland	5	113,588,000
United Kingdom	9	89,425,000
Austria	7	73,219,000
Switzerland	5	64,585,000
France	6	61,884,600
Finland	9	42,880,715
Latvia	1	29,200,000
Czech Republic	1	21,535,000
Russian Federation	1	11,680,000
Serbia and Montenegro	2	9,460,800
Romania	3	7,350,000
Spain	1	-
Total	**149**	**1,799,350,187**

Hannappel et al., 2013

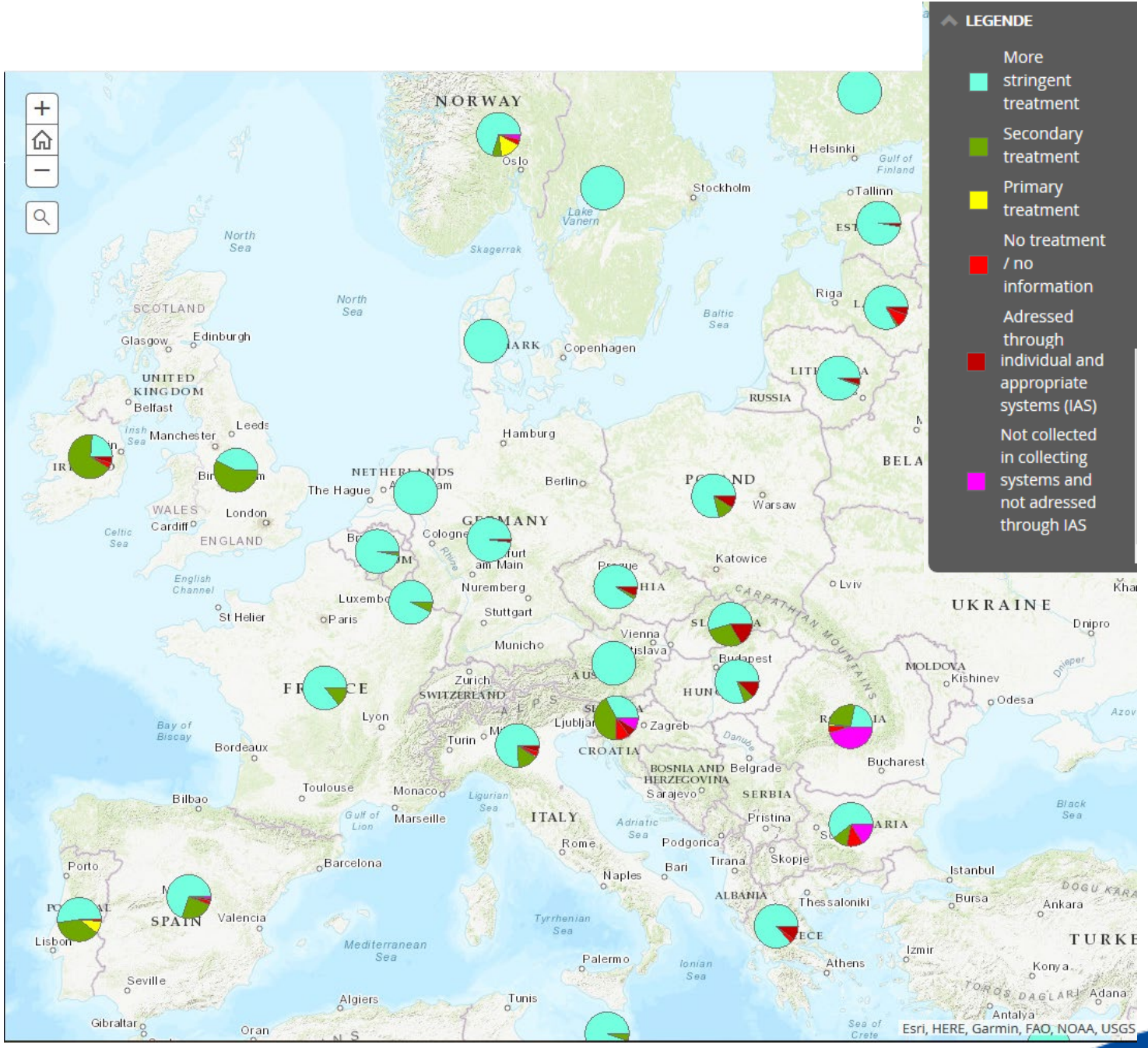
Upgrading of existing sites-
Post-treatment technologies for BF



Kuehne & Mueller 2000

Wastewater

- Implementation status of UWWTD
- Treatment level of ww agglomerations ≥ 2,000 p.e.
- Still demand for appropriate treatment

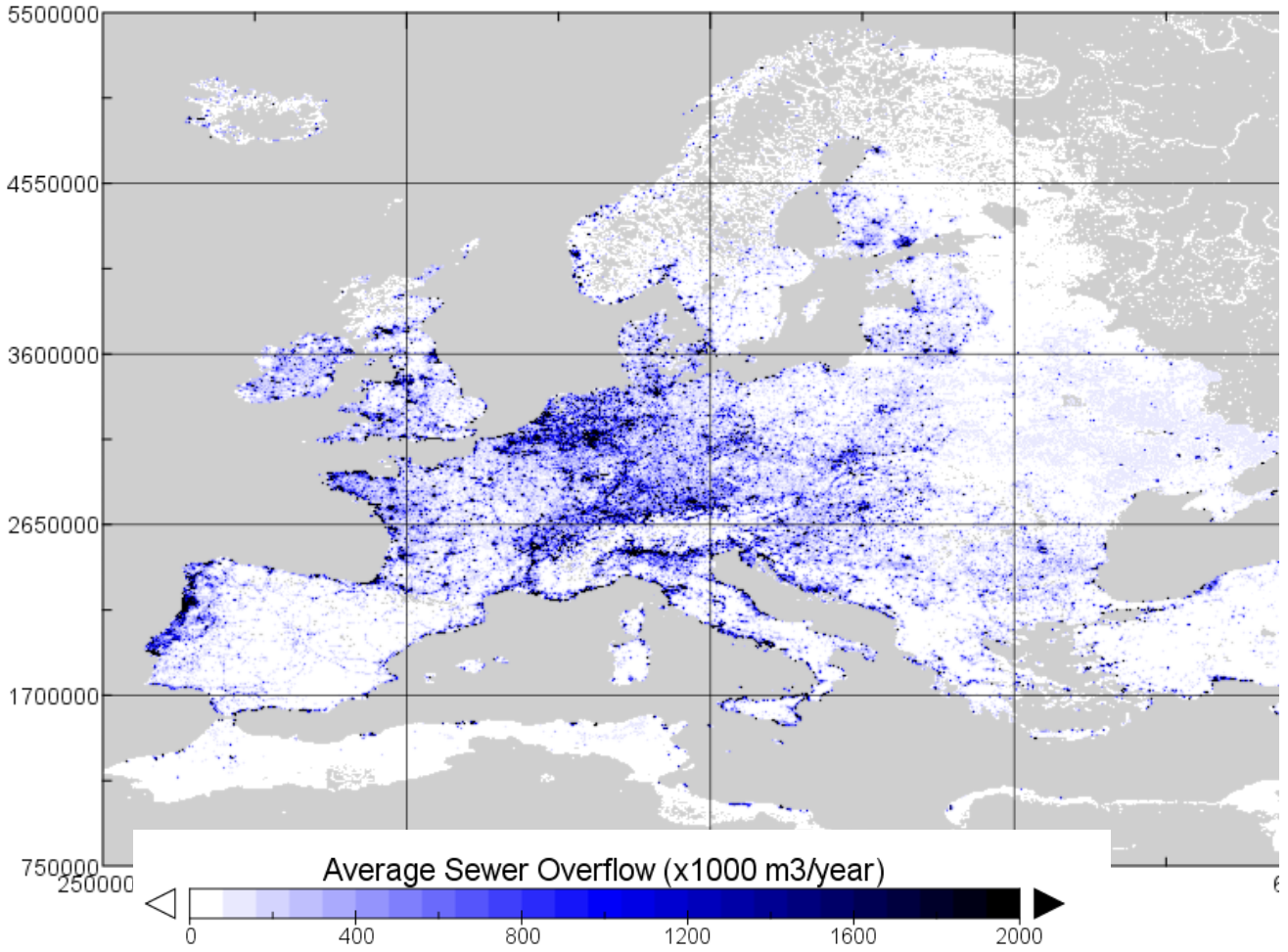


Urban waste water treatment map (EEA, 2016)

Average sewer overflows (1990-2014) modelled results

'Member States that are particularly at risk for the consequences of heavy rain are: Belgium, Croatia, Italy, Luxembourg, the Netherlands, Portugal, Romania and Slovenia. The list includes several Mediterranean countries, at risk for heavy rainfall, which may be intense, of short duration, following a dry period and potentially leading to flash floods and storm water overflows'

(Milieu Study, 2016)



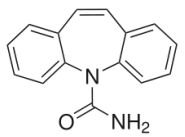
Pistocchi and de Roo, 2016

Micropollutants in water and wastewater

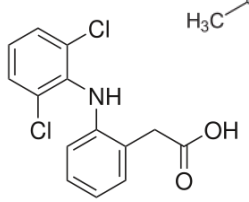
- Residues from e.g. pharmaceuticals, personal care products, industrial chemicals or pesticides
- WWTP are point sources for micropollutant release
- Analysis capable of detecting more and more compounds in ng/L range
- Biological effect assays can support integral assessment
- Full-scale technologies have been implemented
  - Ozone
  - Activated carbon

Legal requirements in Switzerland on micropollutants removal

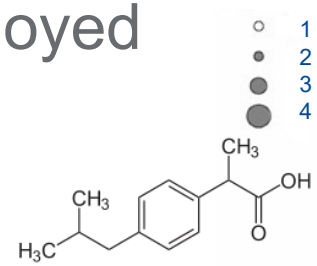
- Swiss Federal Office for the Environment (FOEN) initiated the national project “Strategy MicroPoll” in 2006
- Revision of the Swiss Water Protection and Act Ordinance, upgrading WWTP by a tertiary treatment step for improved removal of MP
- Most likely technologies to be employed
  - Ozonation
  - Activated carbon adsorption (PAC, GAC)



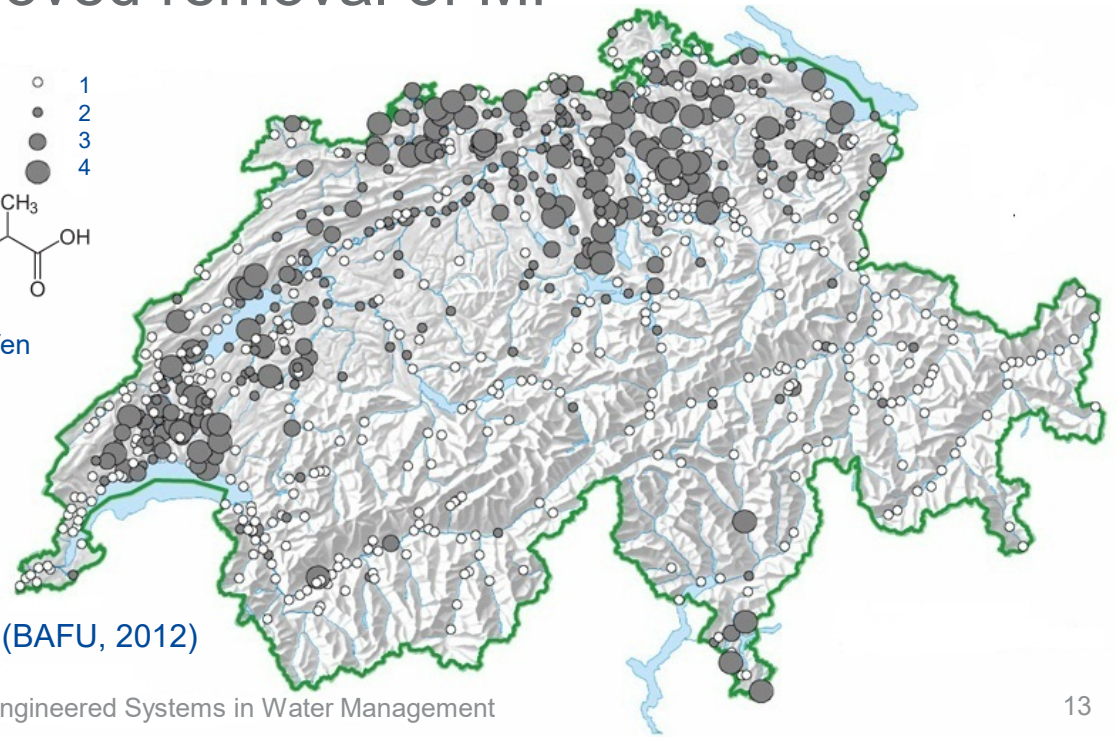
Carbamazepine



Diclofenac



Ibuprofen

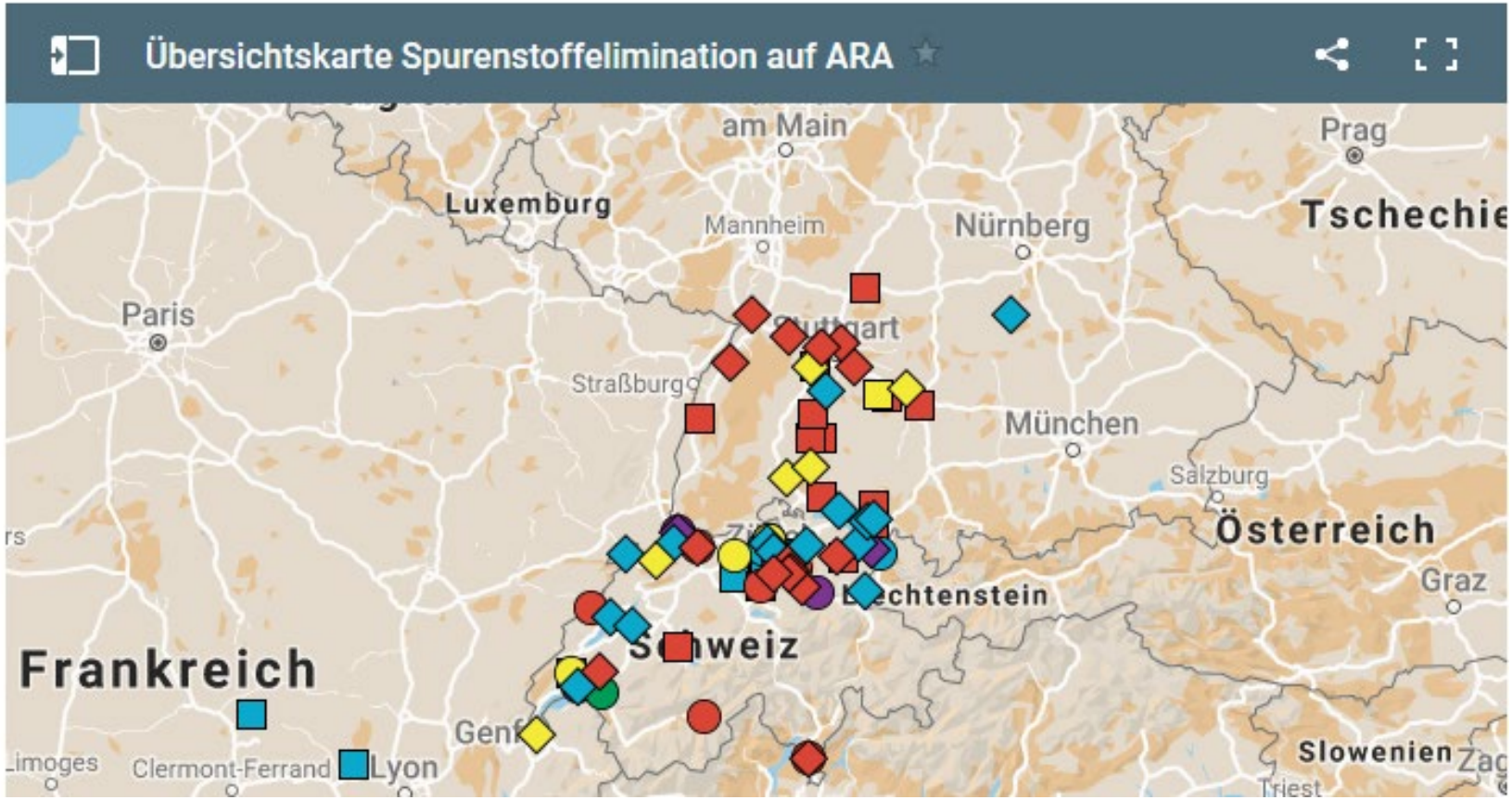


Factor of exceedances of quality criteria for Azithromycin, Carbamazepin, Clarithromycin, Diazinon, Diclofenac, Ibuprofen in Switzerland in 2010 (BAFU, 2012)

Micropollutant removal in wastewater treatment

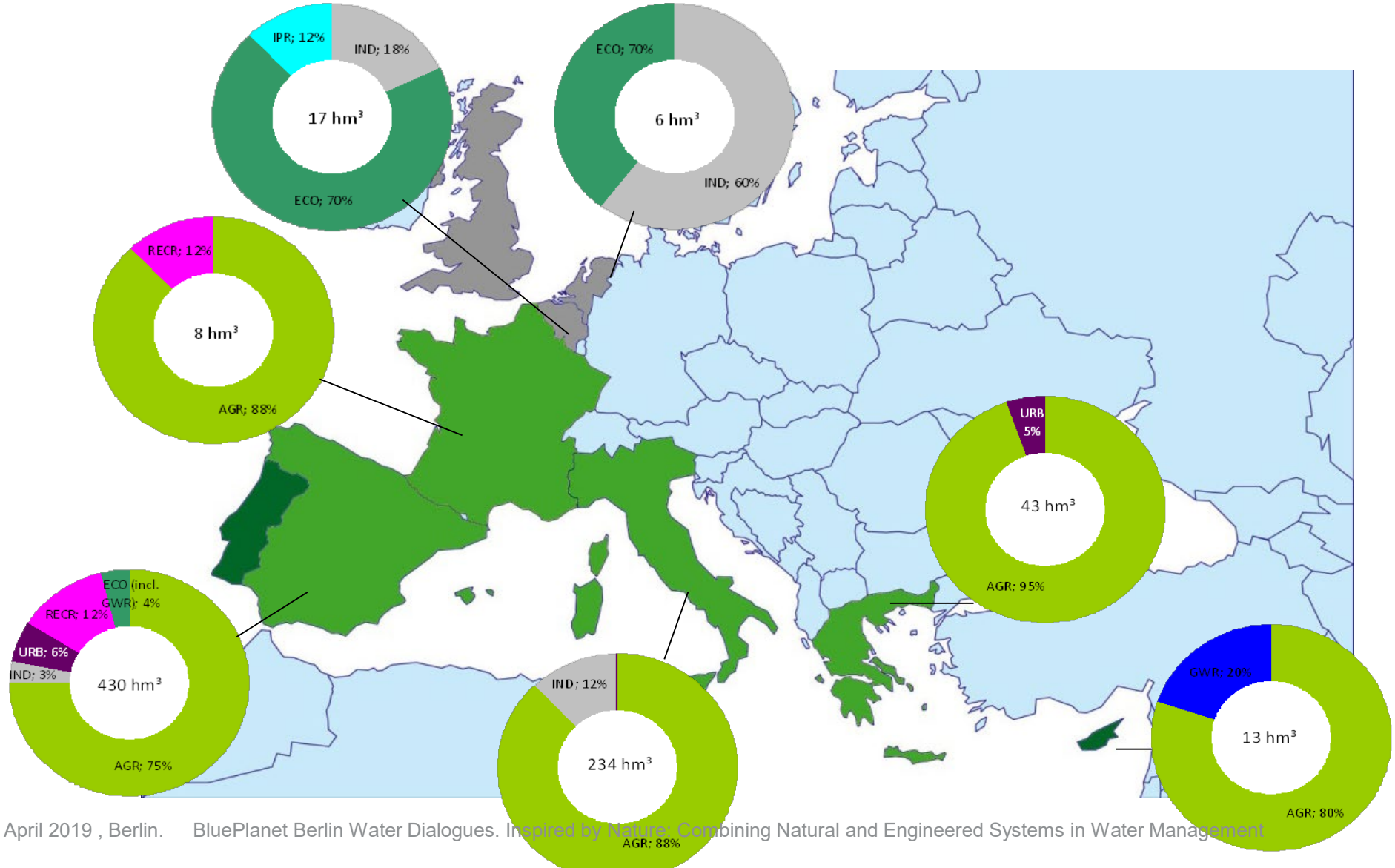
Legende: Ozonung | PAK | GAK | Ferrat | mehrere Verfahren

Umsetzung: Betrieb | Forschungsprojekte | Umsetzung: Planung/Bau



VSA, 2019

Water reuse



Data from EUREAU survey and AQUAREC results www.aquarec.org

AquaNES

Demonstrating Synergies in Combined Natural and Engineered Processes for Water Treatment Systems

Facts and figures

Call: H2020-WATER-2015-two-stage, Topic WATER-1b-2015

30 partners: industry & SMEs, utilities, research

Duration: 36 months
(Juni 2016 – Mai 2019)

Demonstrators: 13 sites in Europe, Israel und India

Funding
Horizon 2020 (EU), 7.8 M€
+ SERI (CH) 0.87 M€

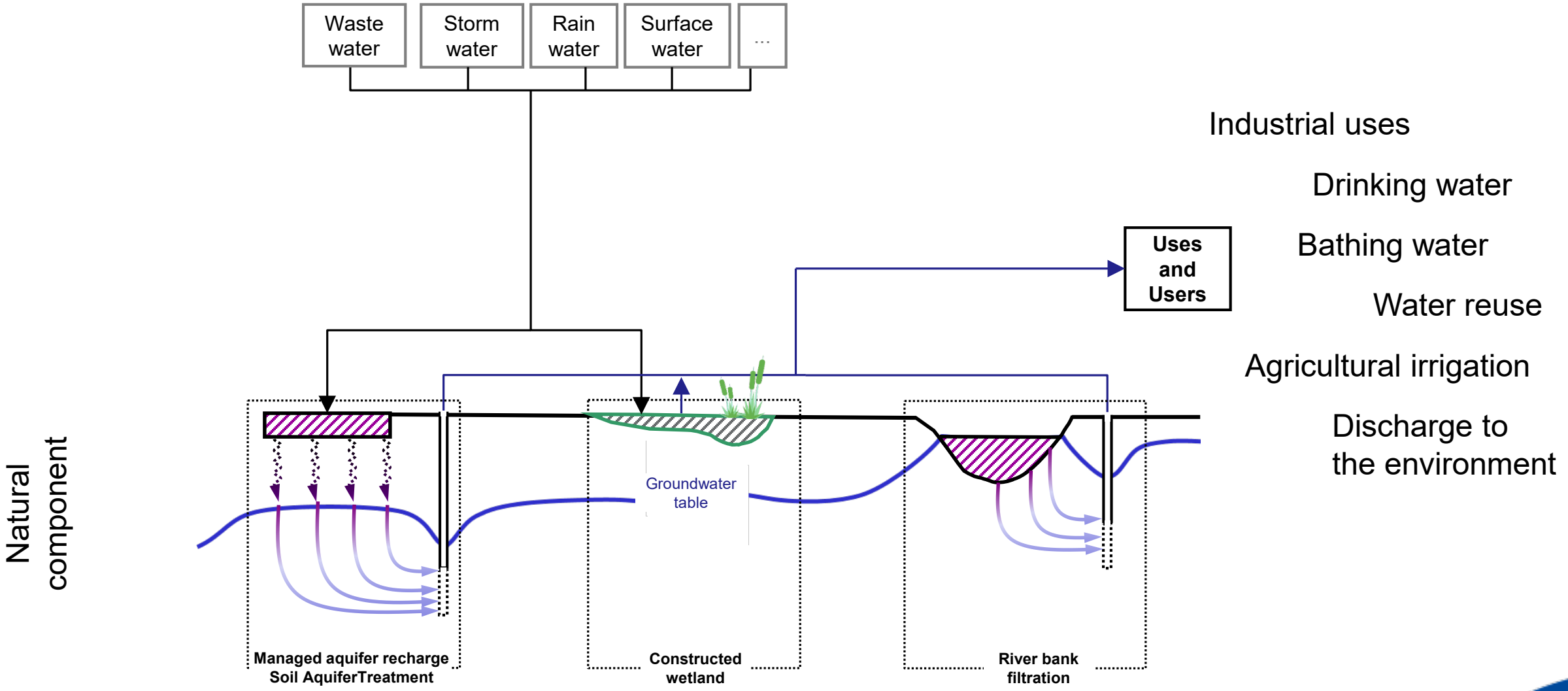
The AquaNES Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 689450

SMEs & Industry

Water Utilities

Universities & Research Institutions

Water treatment by nature-based processes



Industrial uses

Drinking water

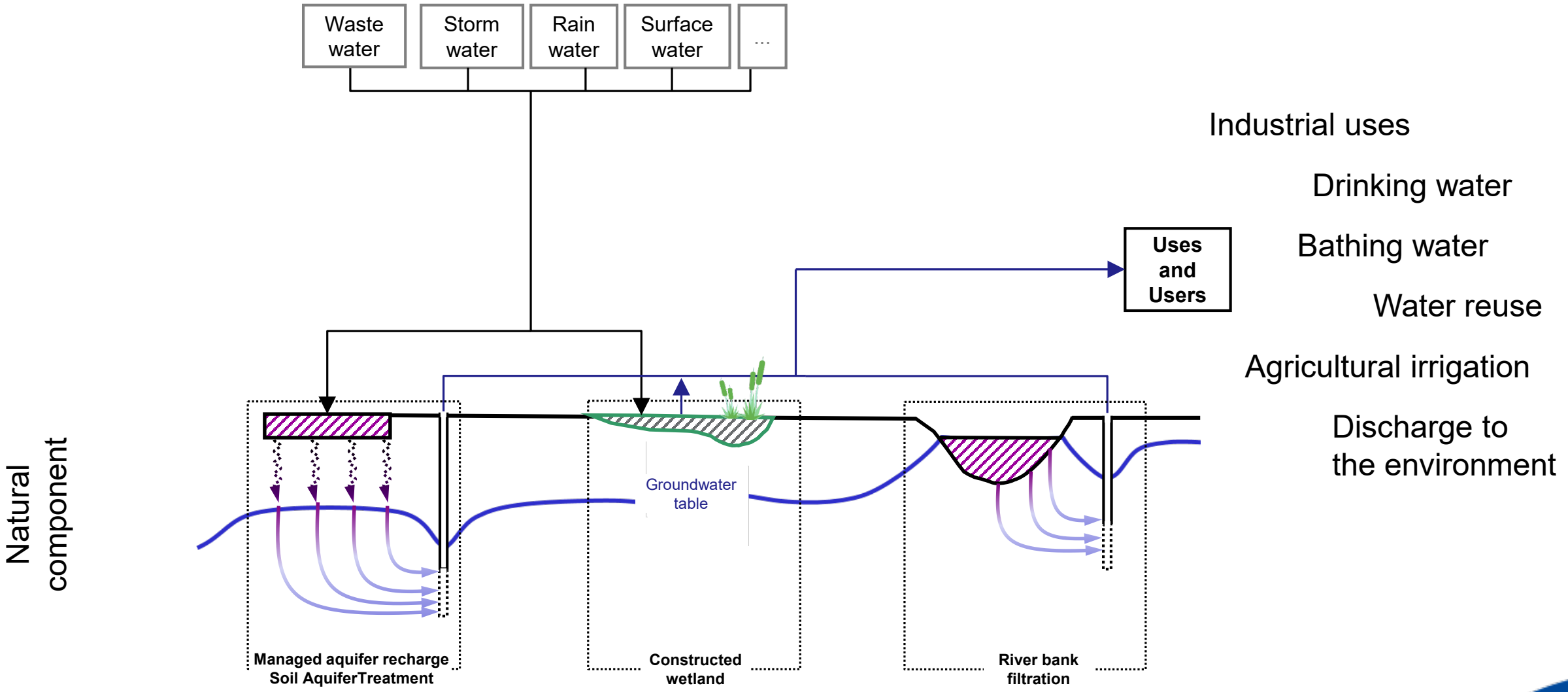
Bathing water

Water reuse

Agricultural irrigation

Discharge to the environment

Project concept



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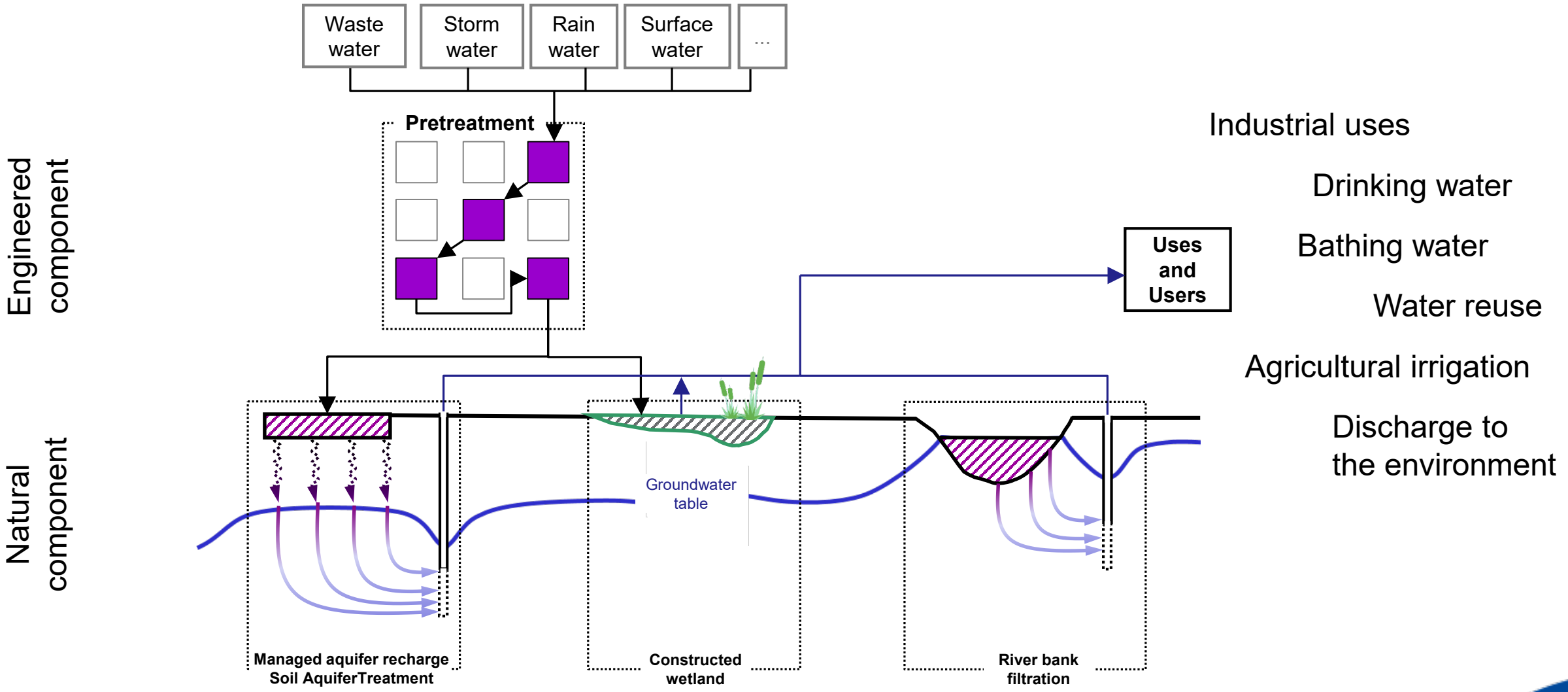

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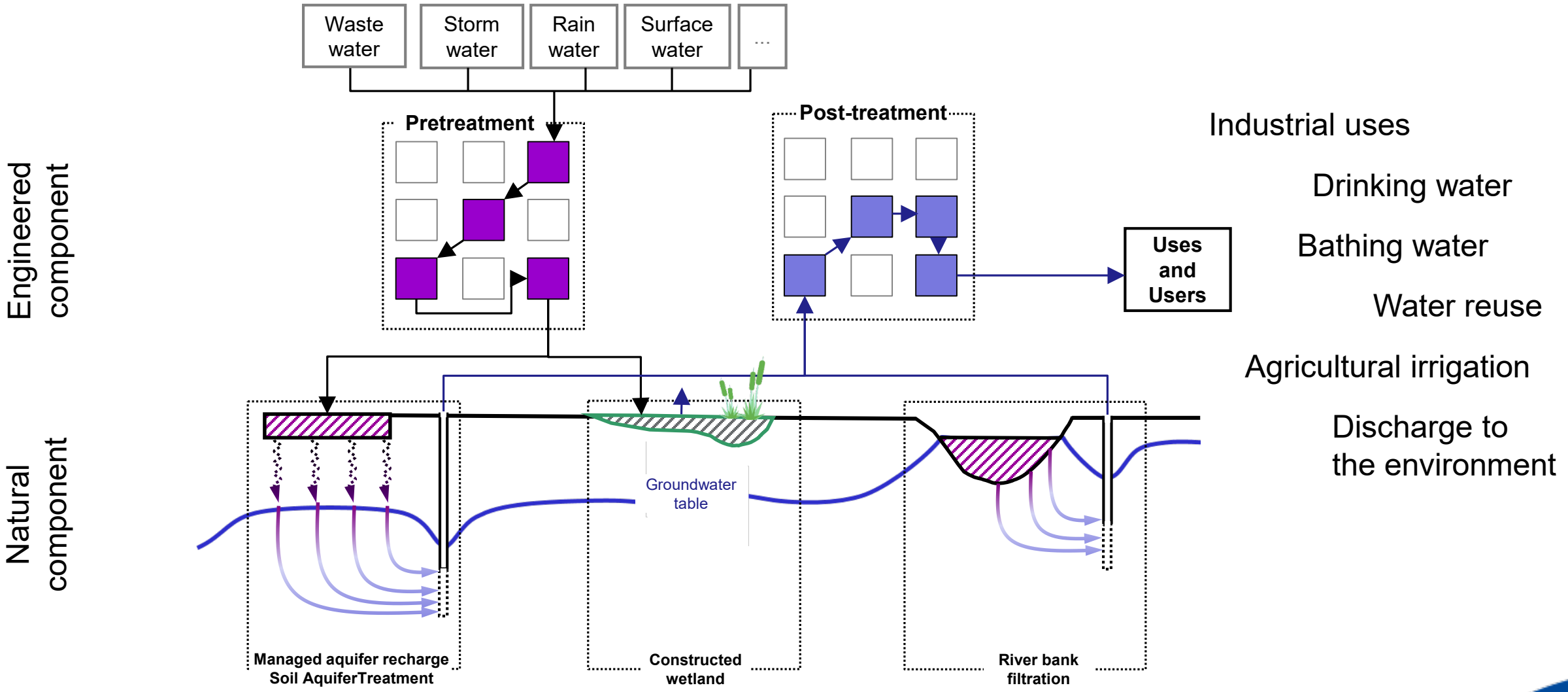
Project concept - cNES



Industrial uses

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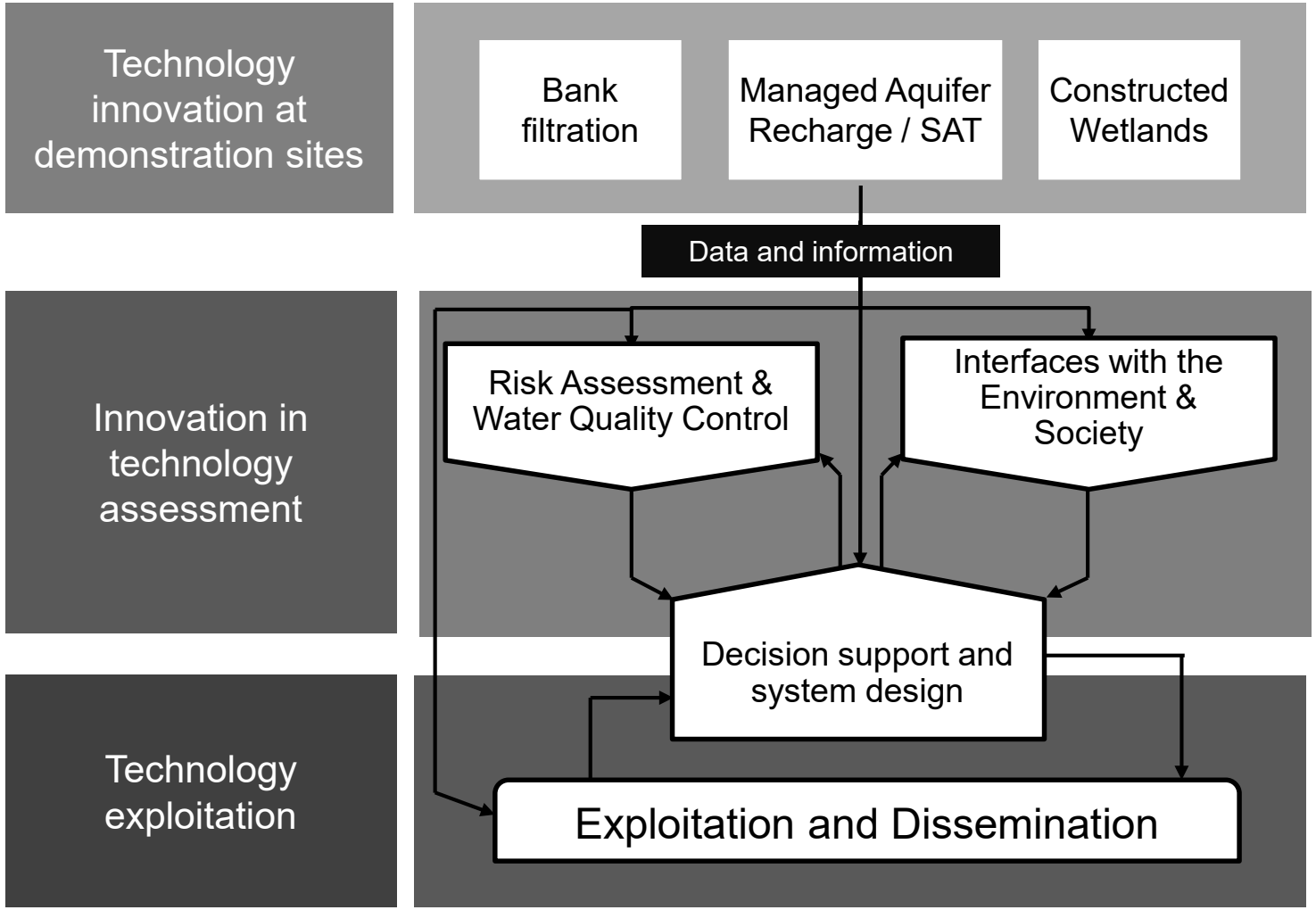
Challenges and objectives

Promotion of cNES* up-take by

- Increasing the **understanding of the capacity** of natural treatment steps
  - Enhance and maintain performance through adequate pre-treatment
  - Make up for variation through post-treatment, complement
- **Assuring water quality**
  - Micropollutants, pathogens and indicators, antibiotic ARG, nutrients
- Developing adapted **operating and monitoring concepts**
- Assessing the **environmental impact (& benefits) and costs**
  - Energy demand, use of chemicals …
  - Land requirements and use
- Providing **decision support**

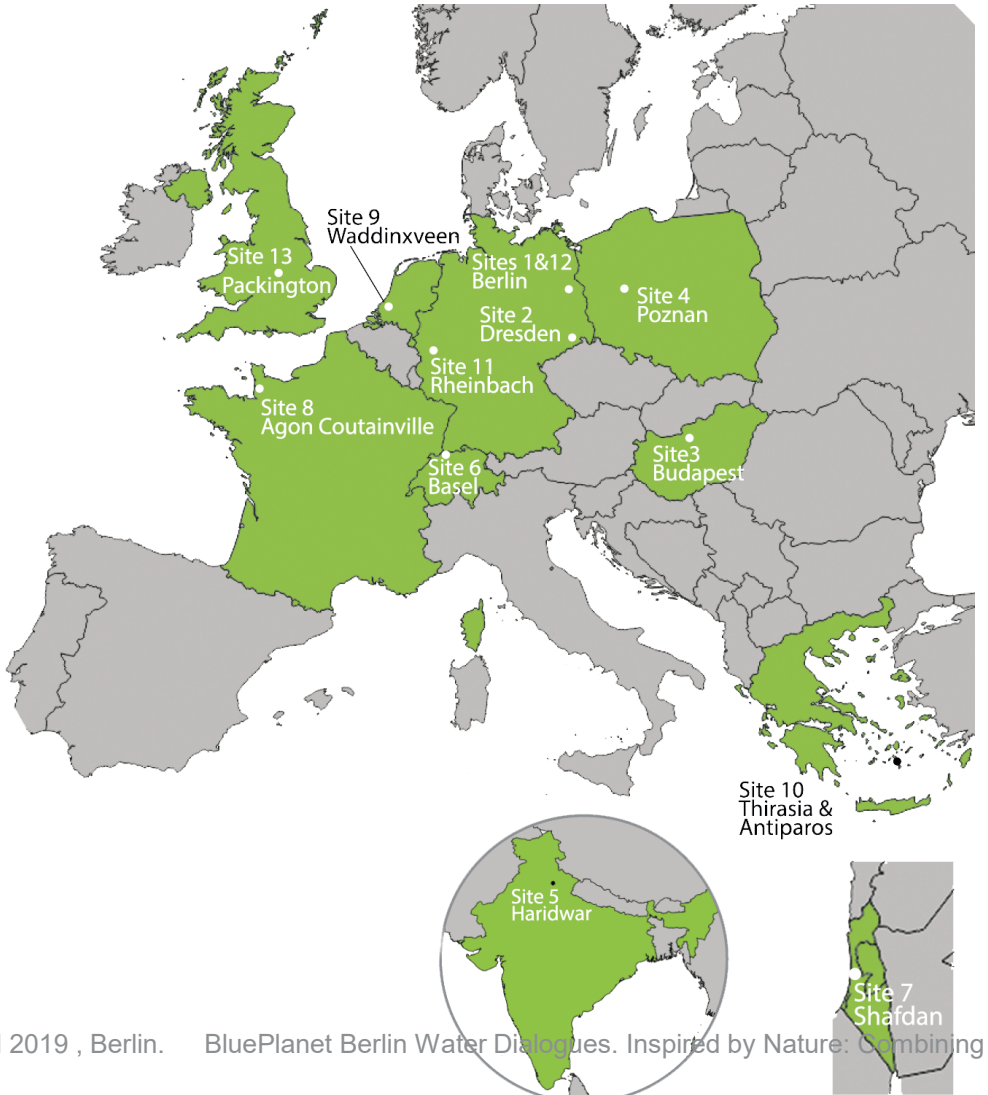
* combined Natural and Engineered Systems

Working approach



- Demonstrate a variety of cNES for a ranges of water treatment purposes in relevant scale:
- assess their performance and describe associated risks and benefits beyond treatment function
- Derive strategies for market-uptake

Demonstration sites locations



- Drinking water production from intensively used surface water
- Adapted wastewater treatment for *'small communities'* or for enhanced removal of certain target compounds
- Water reuse

Demonstration sites: technology combinations

- Oxidative pre-treatment (O_3, H_2O_2+UV, electropulse, solar photocatalysis – TiO_2)
- Post-treatment with membranes (UF, NF, RO) or ozone
- Biofiltration and biological activated carbon filtration (BAC)
- Disinfection processes (electrochlorination, UV)
- Sorptive and biological P-removal (algae reactor)

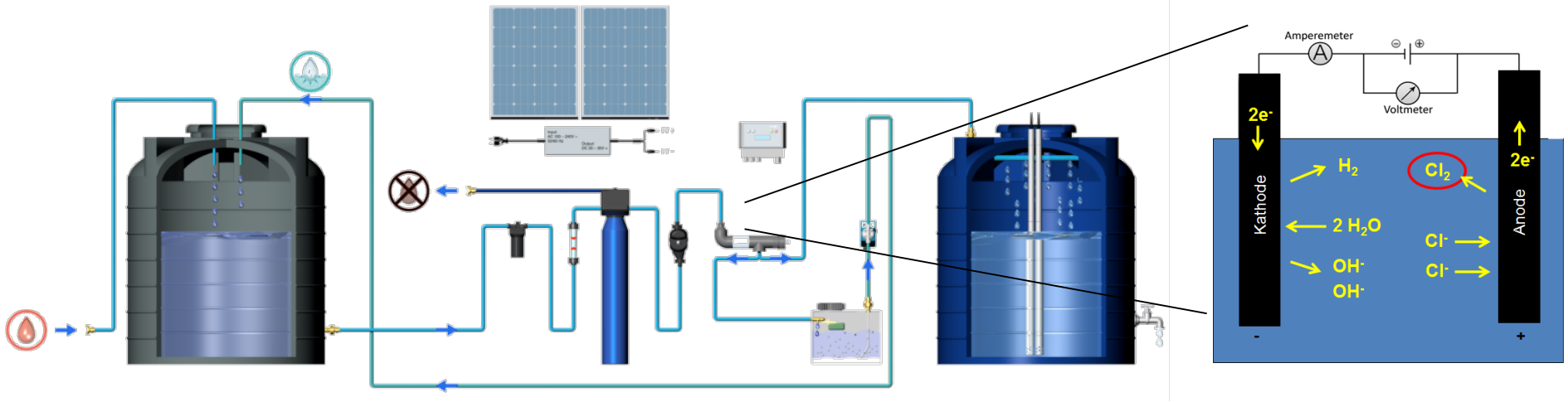
Advanced oxidation processes in AquaNES

		Site no. 6 Lange Erlen, CH	Site no. 7 Shafdan, IL	Site no. 12 Berlin, DE	Site 4, Poznan, PL
	Water use	Drinking water production	Wastewater reuse	Wastewater discharge	Drinking water
Process	Engineered	UV+H_2O_2	O_3 / Electropulse	O_3	O_3
Process	Natural	Managed aquifer recharge	Soil-Aquifer treatment, SAT	Constructed wetland	Bank filtration
	Purpose	**Organic micropollutant removal**			Colour, taste, NOM
	Further aspects	bioassays to observe eco-toxicological effects			
			Optimise operation and control; energy & chemical use		
				antibiotic resistance gene	

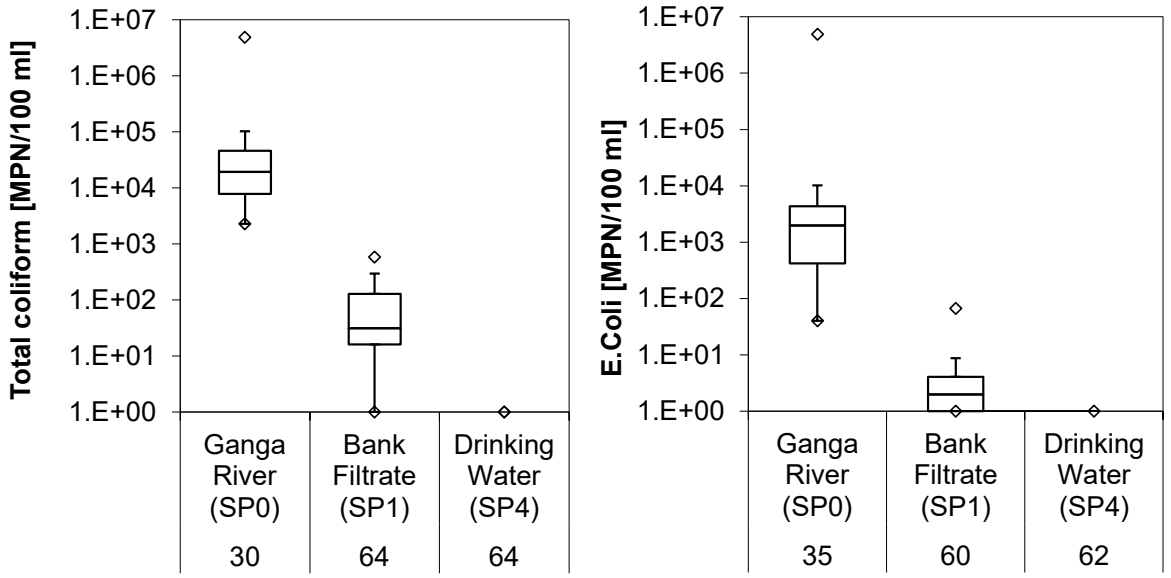
Membrane processes in AquaNES (Session 1, Room I – in the afternoon)

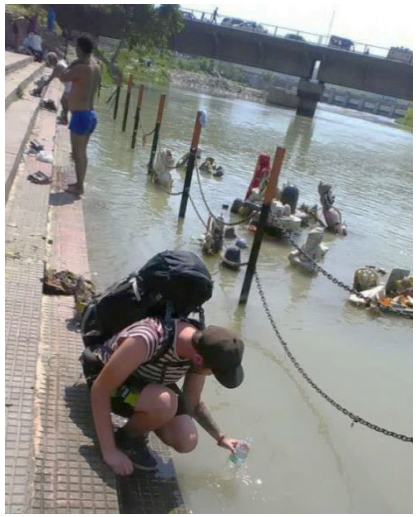
		Site no. 1 Berlin Tiefwerder, DE	Site no. 2 Dresden, DE	Site no. 12 Budapest, HU	Site 10A Thirasia, GR
	Water use	Drinking water production			Wastewater reuse
Process	Engineered	Nanofiltration	Ultrafiltration	Reverse osmosis	Ultrafiltration
Process	Natural	Bankfiltration	Bankfiltration, MAR	Bankfiltration	constructed wetland
	Purpose	**Organic micropollutant removal**	Microbial contaminants		Microbial quality Suspended solids
	Further aspects	Operational perfomance, energy demand			

Solar driven electro-chlorination India (Autarcon)



Results – solar driven electro-chlorination after BF





- No break-through of pathogens during 2.5 a trial phase
- Maximum log-units removal for total coliform was > 6.7
- Performance is indifferent to environmental conditions (e.g. monsoon, floods, etc.)
- Chlorine concentration was maintained around 0.3 mg/L

(Otter et al., 2019)

Thank you for your attention.

AquaNES

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