Intérêts et enjeux scientifiques de la réutilisation des eaux usées traitées

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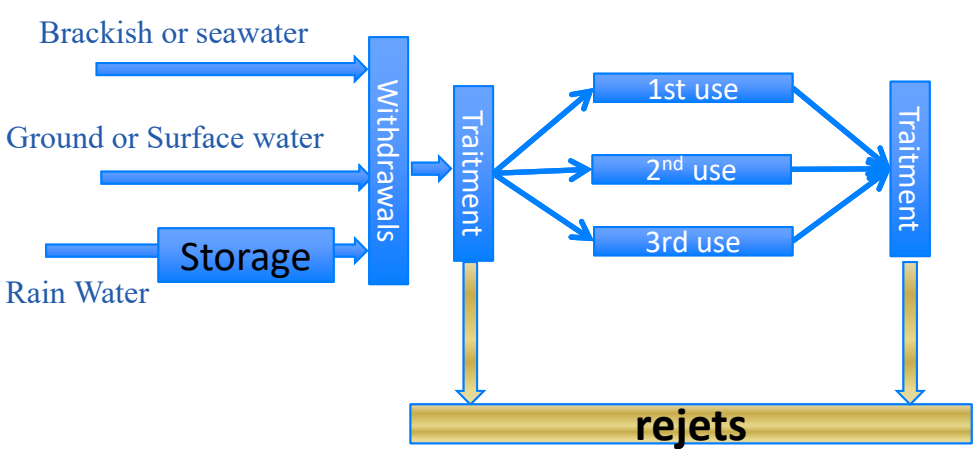
Classical approach, ...



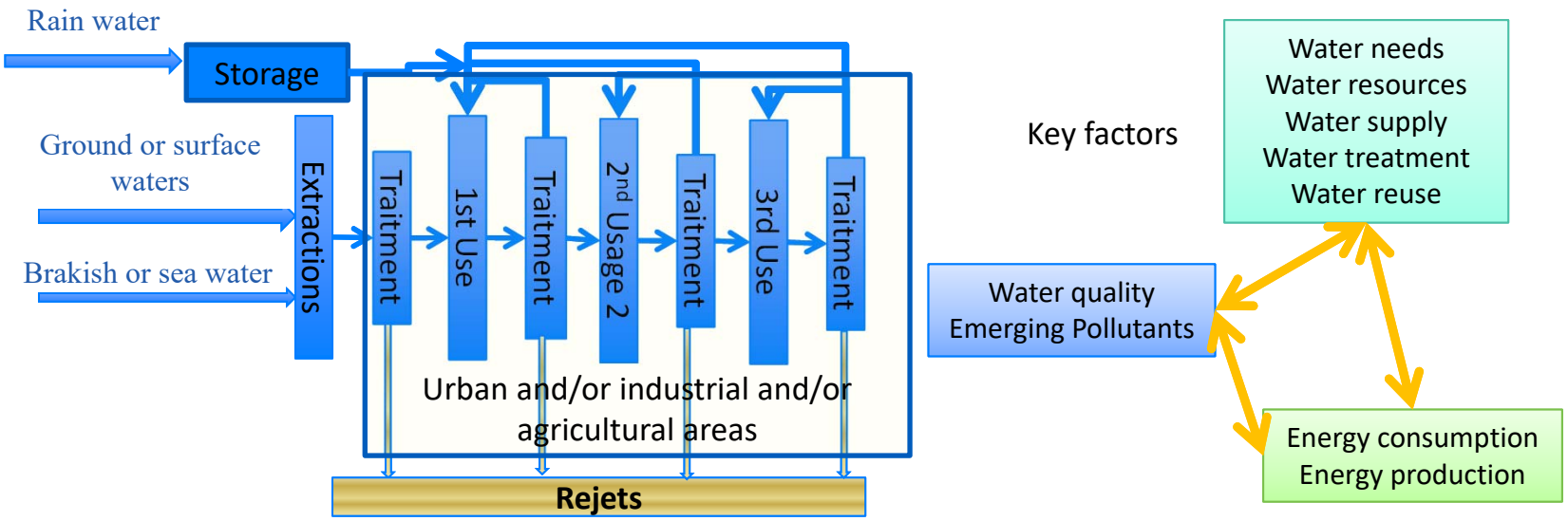
Withdrawals = Discharges = ∑ (uses)

Key factors

- Water needs
- Water resources
- Water supply
- Water treatment
- Water reuse
- Water quality
- Emerging Pollutants
- Energy consumption
- Energy production

Simple and flexible approach that requires a lot of resources, and
All water uses are in competition … use conflicts

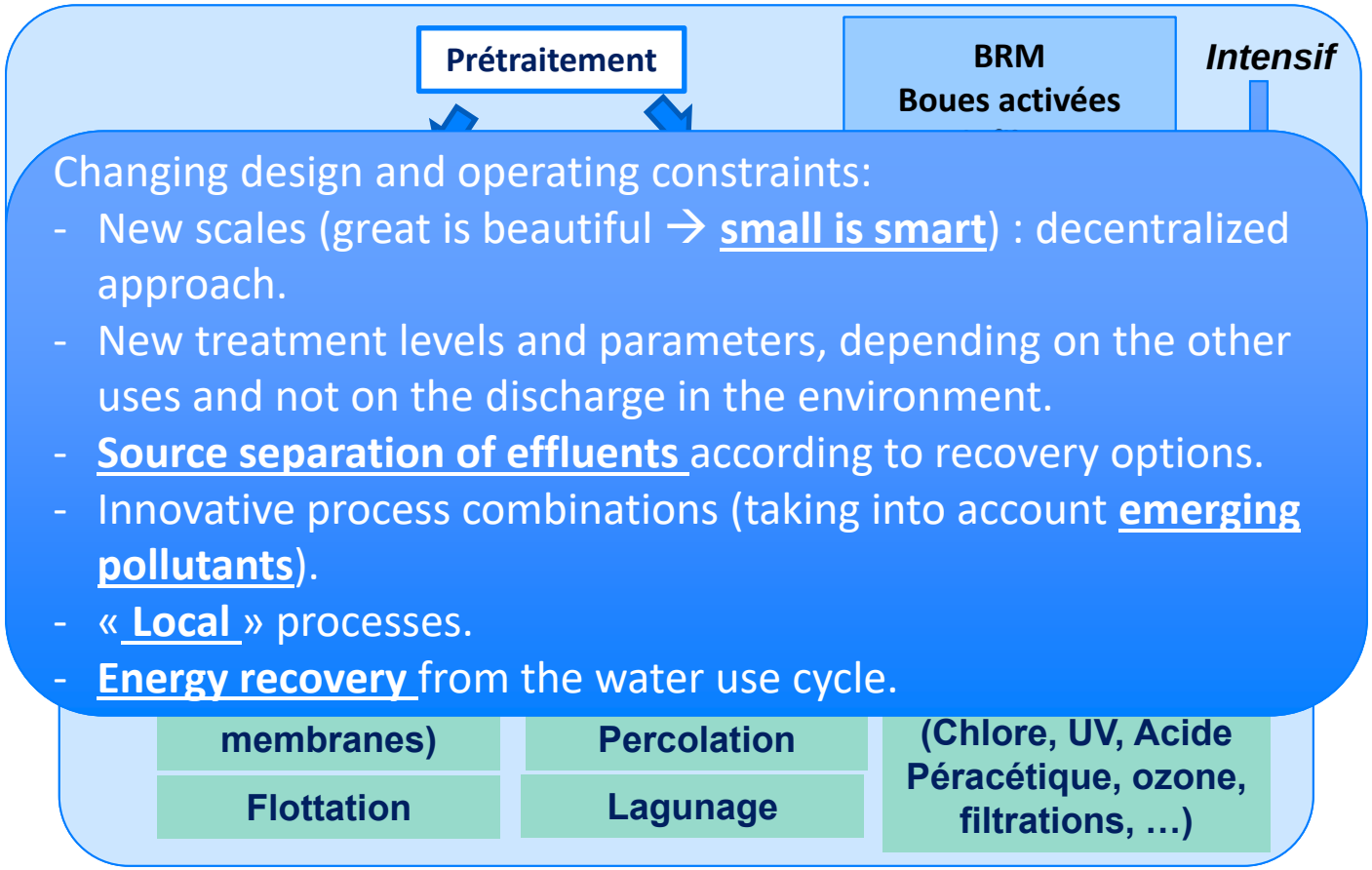
… to reuse approach



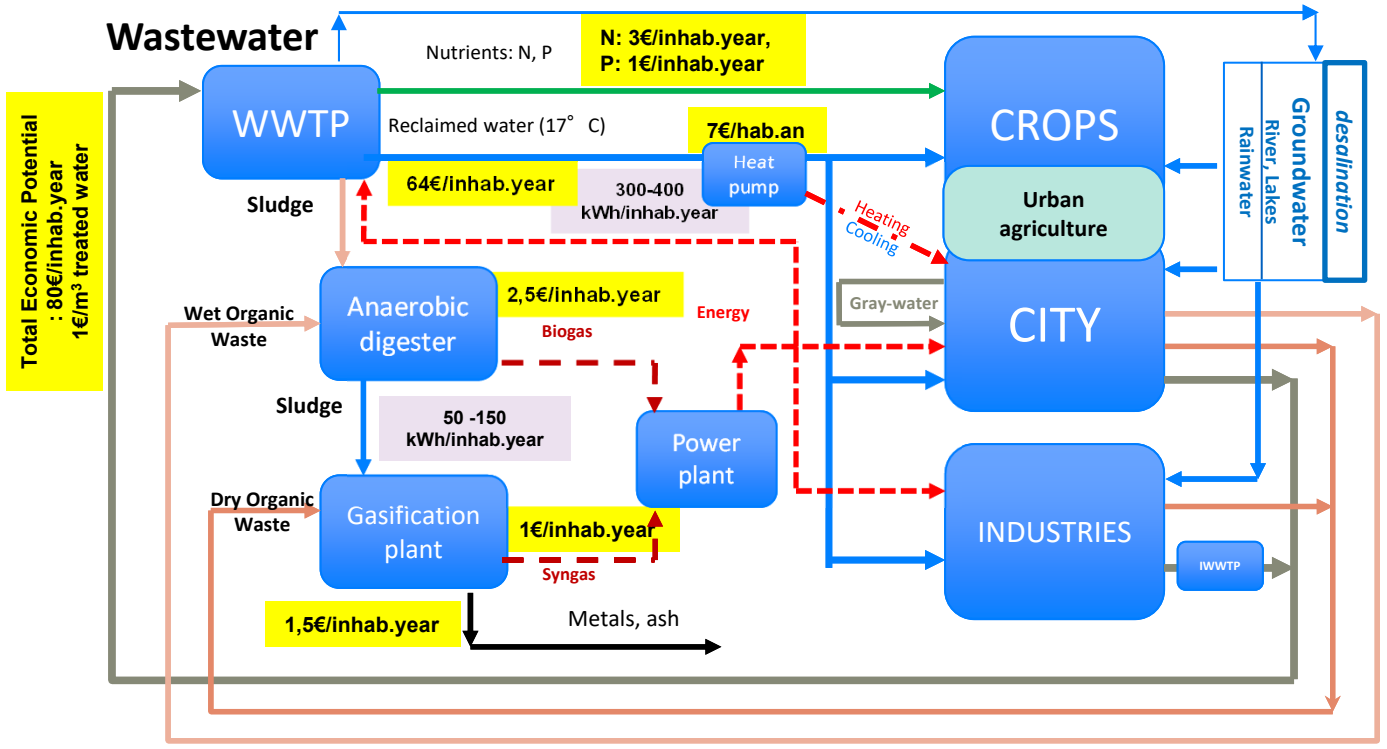
Discharges ≠ Withdrawals ≈ 10-20 % 10-20% total requirements

Complex approach, unic solution, that requires less resources

Wastewater treatment processes

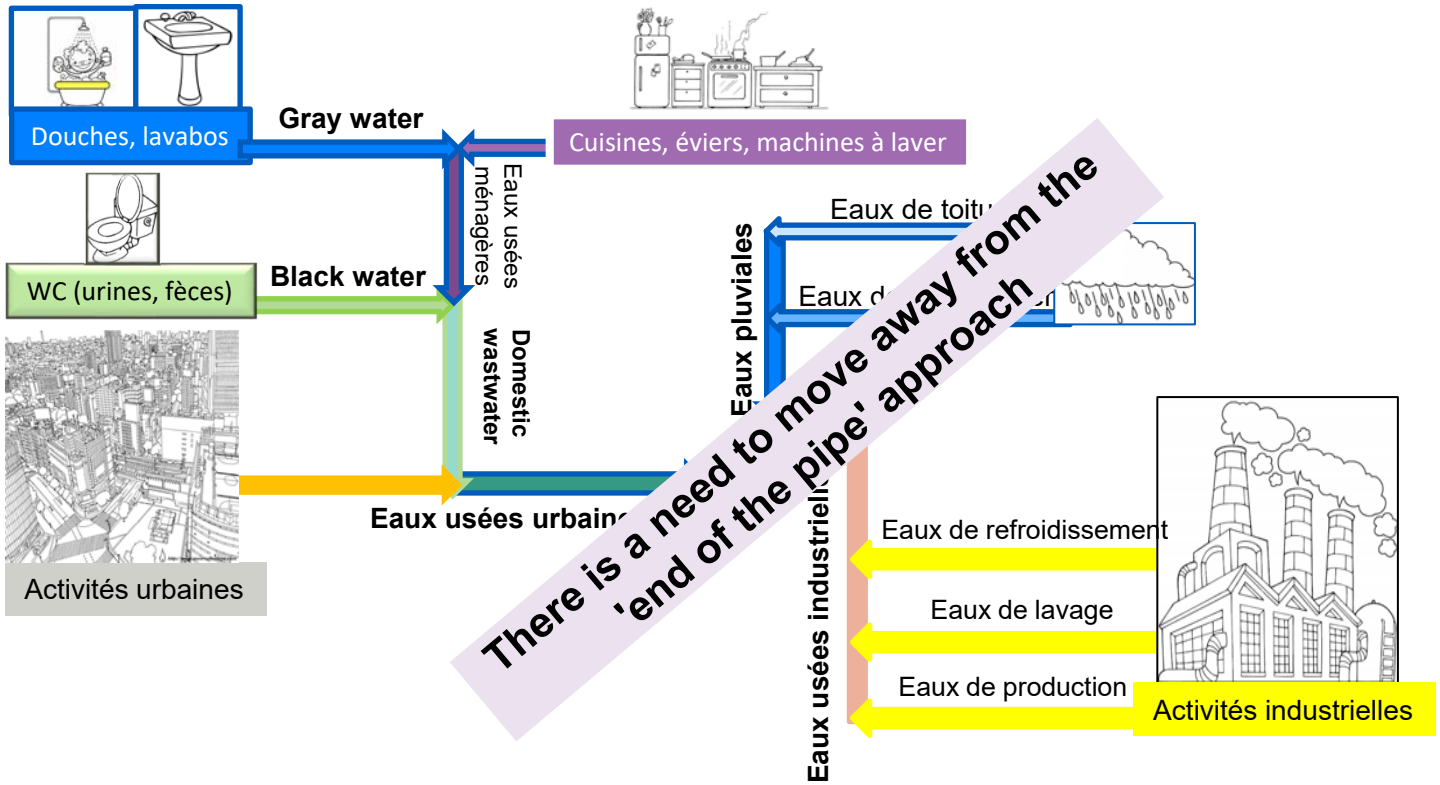


Wastewater is a resource (materials and energy)

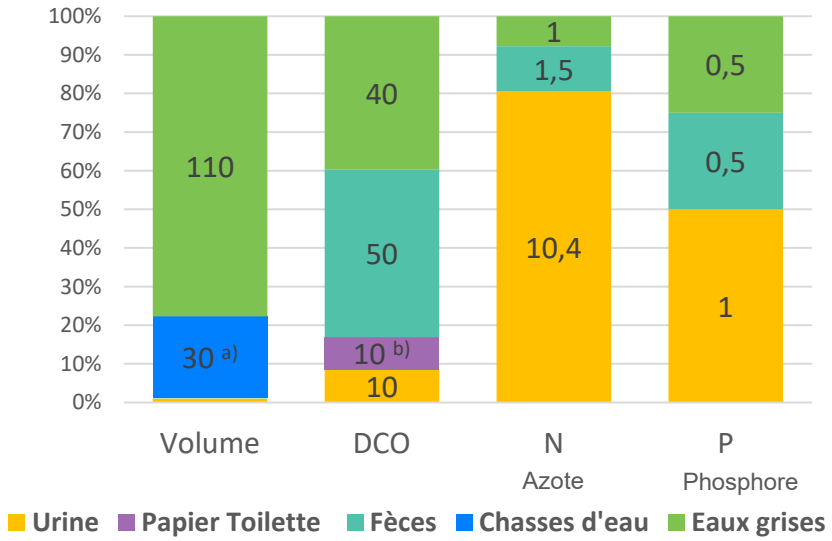


N. Roche (2020)

The different types of wastewater



Séparation à la source : valorisation & ségrégation des risques



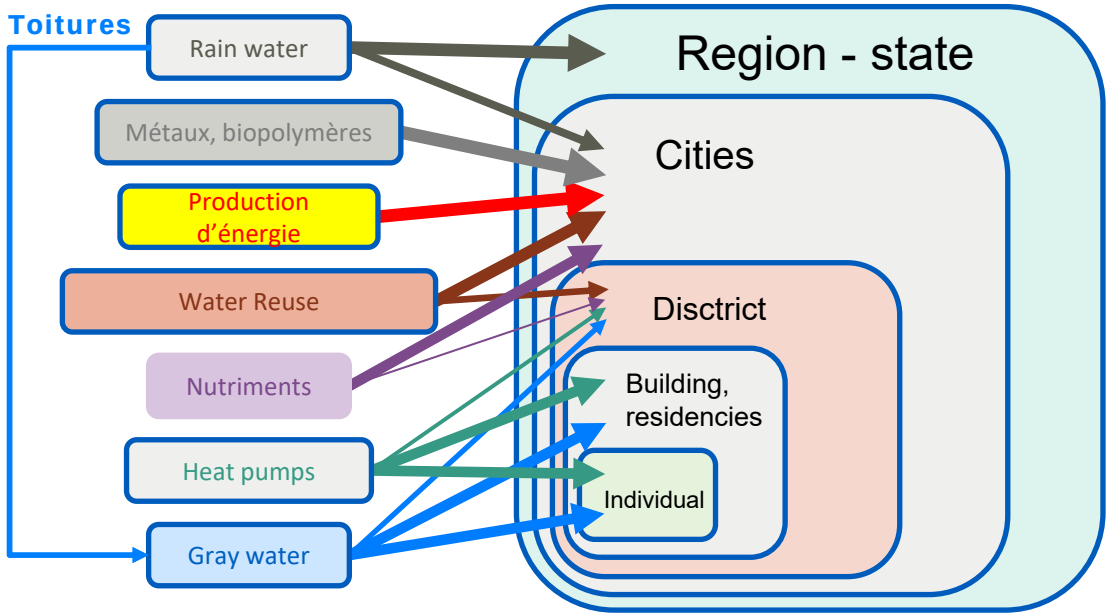
Valeurs : en g/pers/j et L/pers/j

(F. Meinzinger et Oldenburg 2009) [a](F. Meinzinger, et al., 2010 [c] à partir de (Friedler, et al., 1996; Almeida, et al., 1999)

Risques liés à la présence des pathogènes : Fèces (96%), Eaux Grises (3%), Urines (1%)

Risques liés à la présence de résidus médicamenteux : Urines (67%), Fèces (33%)

Wastewater is a resource: what scales?



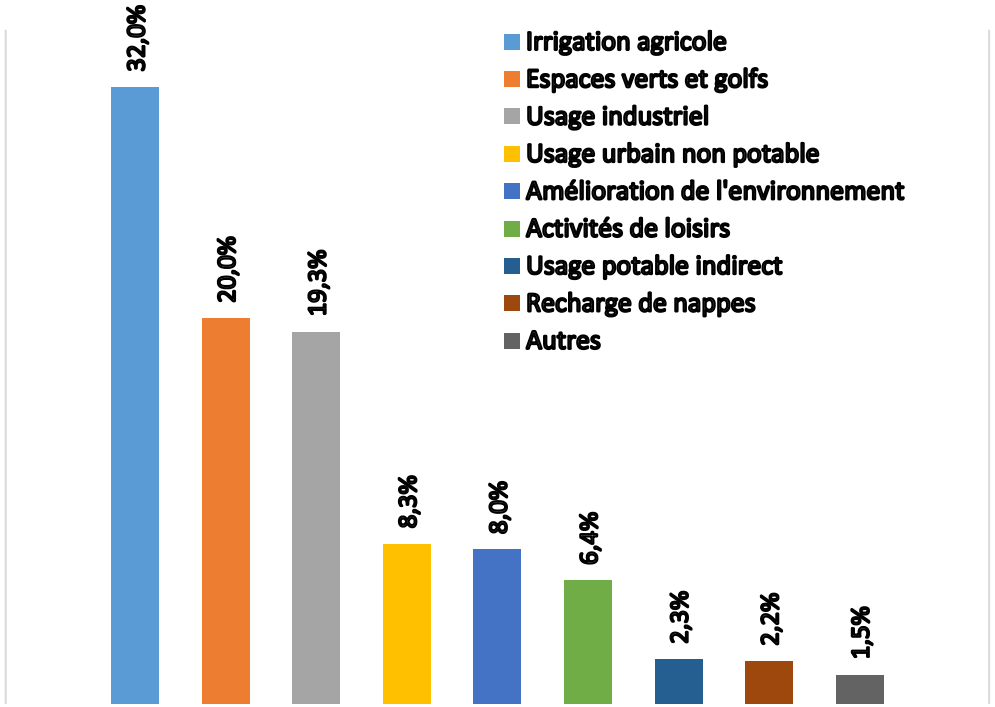
N. Roche (2020)

Urban Reclaimed Water Use Approval Ratings

Recycled water use	Number (%) of respondents who use	Number (%) of respondents who don't use	Number (%) don't know / refused
Toilet flushing	259 (96.3%)	3 (1.1%)	7 (2.6%)
Garden watering	260 (96.7%)	8 (3.0%)	1 (0.4%)
Car washing	212 (78.8%)	51 (19.0%)	6 (1.1%)
Clothes washing	13 (4.8%)	247 (91.8%)	9 (3.3%)
Drinking	4 (1.5%)	263 (97.8%)	2 (0.7%)
Cooking	2 (0.7%)	264 (98.1%)	3 (1.1%)
Showering	4 (1.5%)	262 (97.4%)	3 (1.1%)

Hurlimann, A., 2008. *Community Attitudes to Recycled Water Use:an Urban Australian Case Study*, Salisbury: The Cooperative Research Centre for Water Quality and Treatment.

Répartition des volumes des eaux usées traitées réutilisées par usage (monde)



Source: GWI/PUB Water Reuse Inventory, 2010

Quelques exemples :

Vitoria (Espagne) : 13 Mm^3/an, irrigation : STEP + coag/floc + filtration + désinfection + stockage (7 Mm^3)

Milan (Italie) : 90 Mm^3/an, irrigation : STEP + filtration sur sable + désinfection,

<10 EC/100ml

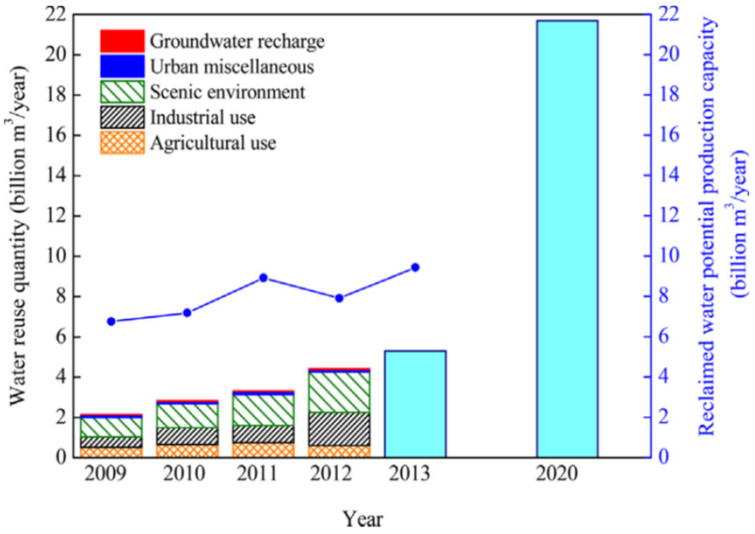
Dan region (Israël) : 100 Mm^3/an, irrigation : STEP + infiltration dans le sol et l'aquifère

Noirmoutier (France) : 0,35 Mm^3/an, irrigation AOC : STEP + lagunage, <1000 EC/100ml

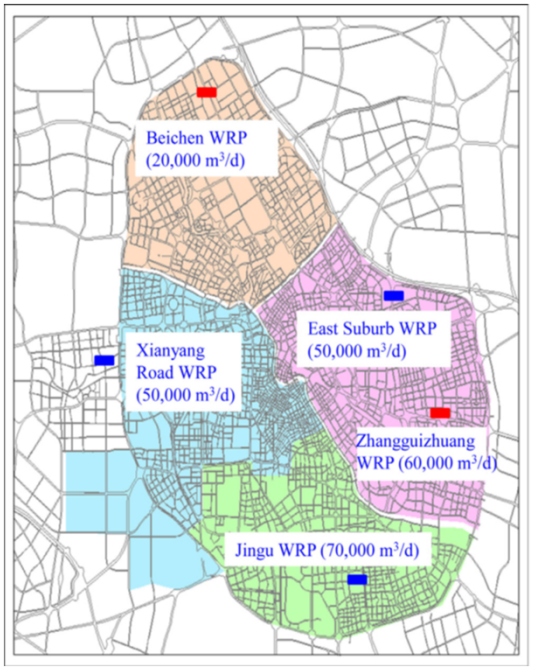
Clermont-Ferrand (France) : 1,2 Mm^3/an, irrigation : STEP + lagunage, <1000 CF/100ml

Bora-Bora (Tahiti) : 0,11 Mm^3/an, espaces verts, nettoyage, incendie, chantiers : STEP + UF

Reuse en Chine :



14 millions de m^3/jour en 2013
4 fois plus en 2030



Ville de Tianjin : STEP à l'intérieur ou proches des zones urbaines denses : traitement différencié selon usage industriel, urbain et domestiques (4 M habitants),

Z. Chen et al., J Resources, Conservation & recycling, 117 (2017) 125-136

Scarcity and reuse in China

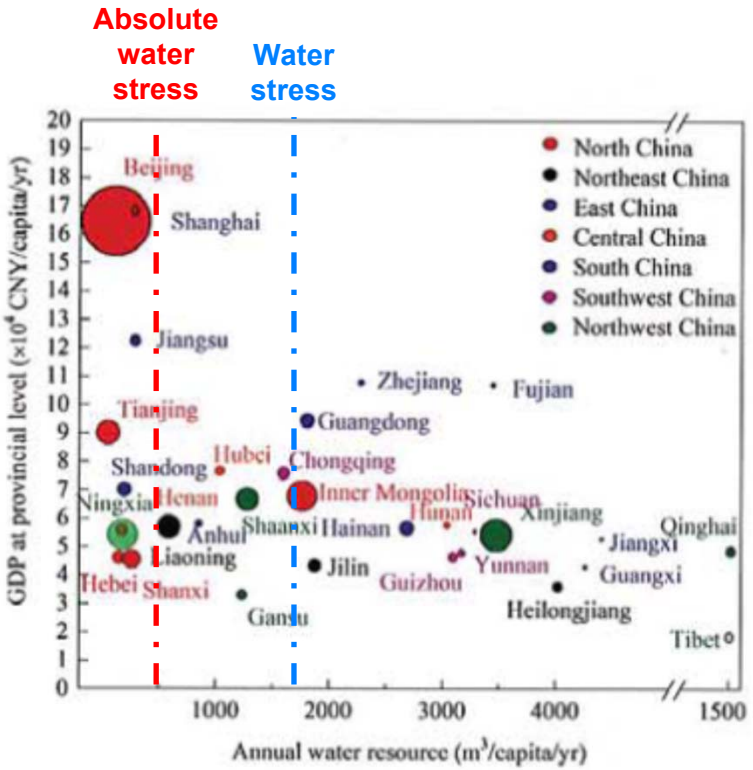


Figure 2. Correlations of the scale of reclaimed water facilities (m^3 per capita per year) in urban areas with water resource quantity and GDP level in 31 provinces of mainland China (2019)

Multiplicité des scénarii, choix des procédés

S. Sadr et al., Journal of Environmental Management, 156 (2015) 97-108

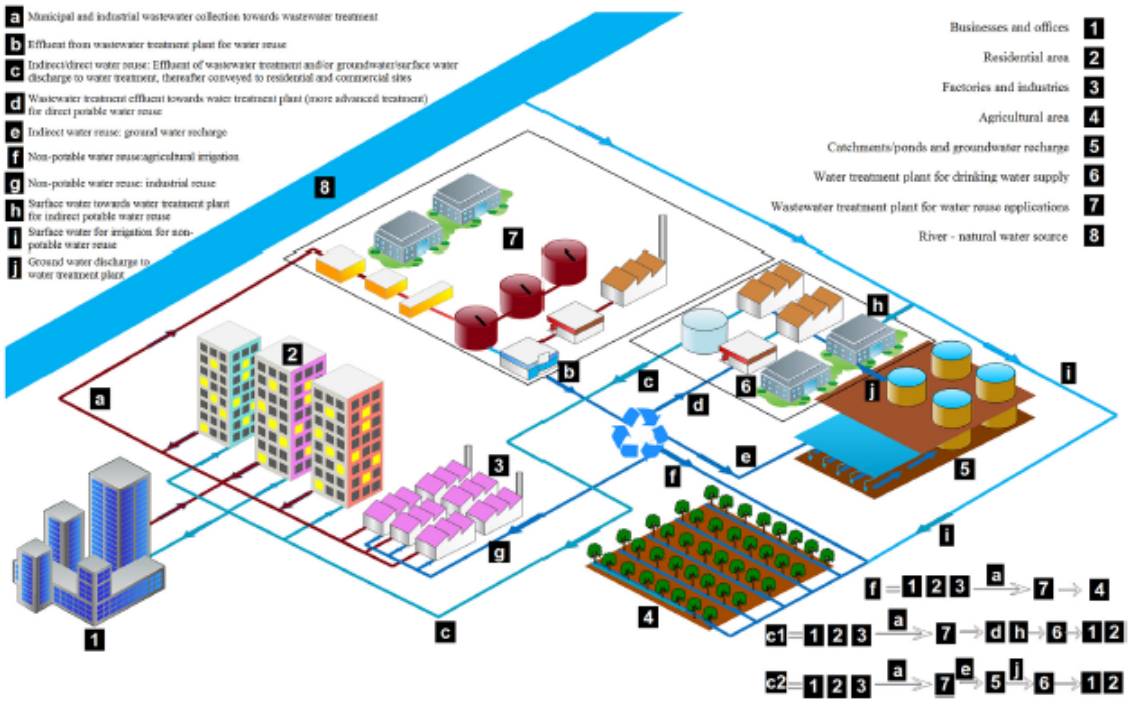
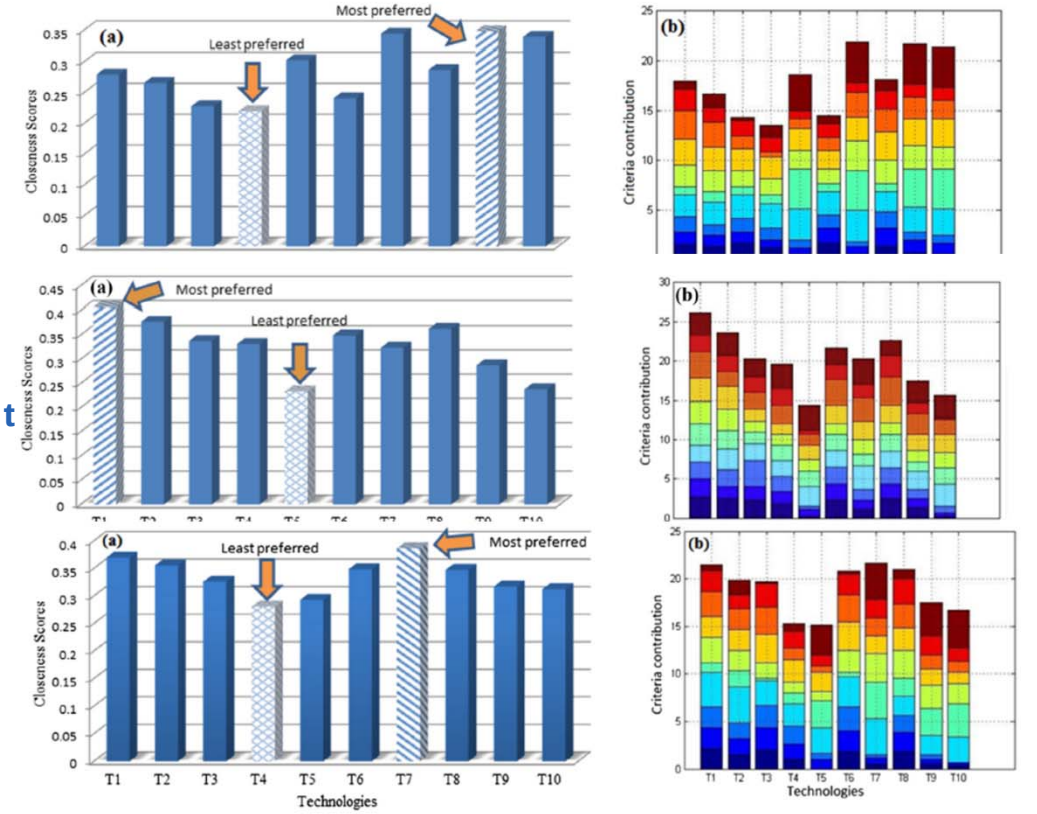


Fig. 2. Illustration of the different possible water reuse applications within a community.

Réutilisation directe
Pays développé

Réutilisation indirecte
Pays en développement

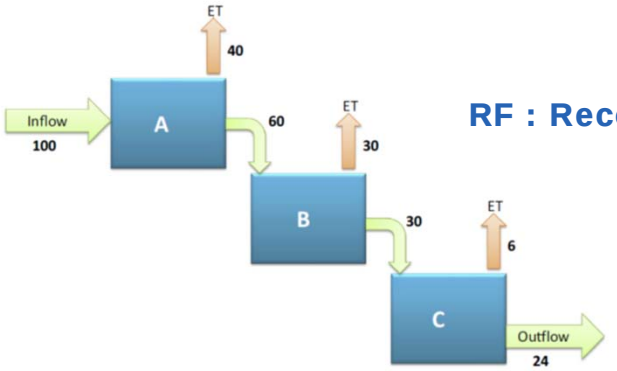
Réutilisation indirecte
Pays développé



T1: Primary treatment + iMBR (Aerobic treatment + MF/UF) + Disinfection
T2: Primary treatment + iMBR (Anaerobic + Anoxic + Aerobic + MF/UF) + Disinfection
T3: Primary treatment + CASP (Anoxic + Aerobic) + MF/UF + Disinfection
T4: Primary treatment + CASP (Anaerobic + Anoxic + Aerobic) + MF/UF + Disinfection
T5: Primary treatment + CASP (Anaerobic + Anoxic + Aerobic) + MF/UF + NF/RO + Disinfection
T6: Primary treatment + Anaerobic treatment + MF/UF + Disinfection
T7: Primary treatment + iMBR (Anoxic + Aerobic + MF/UF) + NF/RO + Disinfection
T8: Primary treatment + Chemically enhanced primary treatment + MF/UF + Disinfection
T9: Primary treatment + Chemically Enhanced Primary Treatment + MF/UF + NF/RO + Disinfection
T10: Primary treatment + Coagulation/flocculation + sand filtration + MF/UF + NF/RO + Chlorination +UV

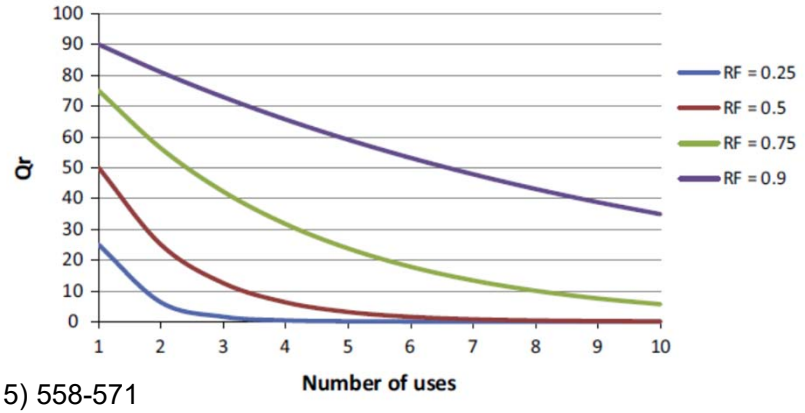
C1: Capital cost
C2: Operation & maintenance Cost
C3: Energy consumption
C4: Impact on the environment
C5: Community acceptance
C6: Adaptability
C7: Ease of construction and deployment
C8: Land requirement
C9: Level of complexity
C10: Water quality and reliability

Impacts des usages sur la réutilisation



RF : Recoverable Fraction

Evolution of the fraction of available flow



J. Simons et al., Journal of Hydrology, 522 (2015) 558-571

Impact de la REUT dans le temps

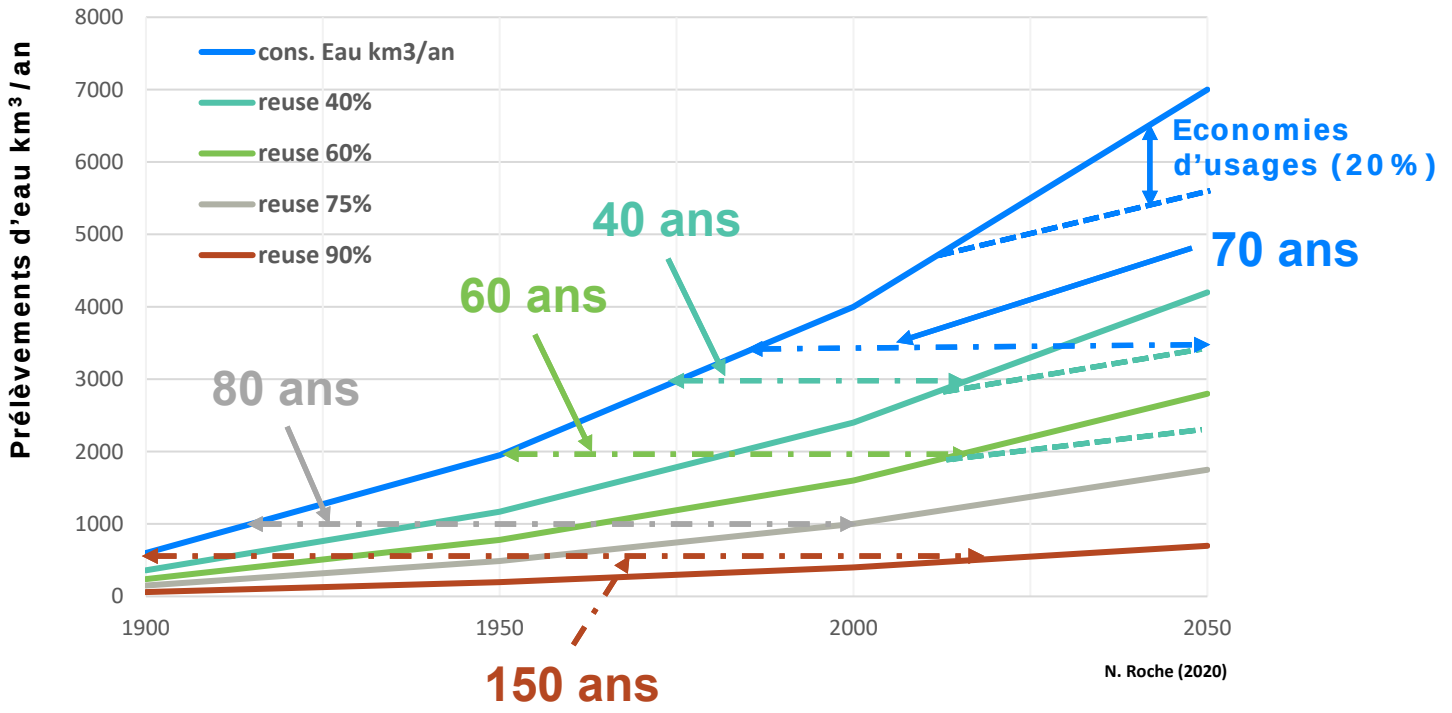


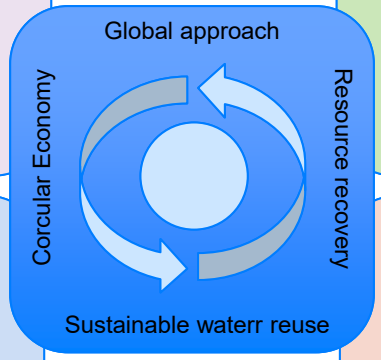
TABLE 14.6 Legislation for Treated Wastewater Reuse

Country	Water Reuse Practice	Existence of Legislation		Contemplating Legislation
		Regulations	Guidelines	
Algeria	✓			
Australia	✓	✓		
Belgium	✓			✓
Bulgaria	✓			✓
Canada	✓		✓	
China	✓	✓		
Cyprus	✓	✓		
Egypt	✓			
France	✓	✓		
Germany	✓			✓
Hellas	✓	✓		
Hungary	✓			✓
India	✓			
Iran	✓	✓		
Israel	✓	✓		
Italy	✓	✓		
Japan	✓	✓		
Jordan	✓		✓	
Kuwait	✓			
Lebanon	✓			
Libya	✓			
Malta	✓			
Mexico	✓	✓		
Morocco	✓	✓		
Namibia	✓			
Oman	✓			
Poland	✓			✓
Rumania	✓			✓
South Africa	✓		✓	
Singapore	✓	✓		
Spain	✓	✓		
Syria	✓			
The Netherlands	✓			
Tunisia	✓	✓		
Turkey	✓	✓		
UK	✓			✓
Yemen	✓			
USA				
Arizona	✓	✓		
California	✓	✓		

Integrated and Interdisciplinary approach : Key factors

Political & decisional factors:
- Funding available
- **Regulation, existing plans and policies**
- Reuse alternatives (agriculture, urban, domestic, industrial)
- Political will
- **Transfer of legal liabilities**

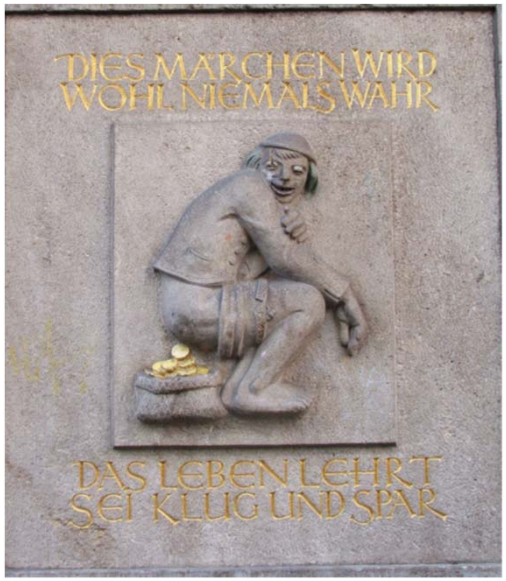
Economic & social factors:
- Treatment costs (inv. + oper.)
- Public percetption
- Reclaimed water demand
- Value of saved water
- Increase of a market thanks to reuse
- Availability of water resources (drought, WSI)



Technologic factors :
- Centralized or decentralized system
- Wastewater quality and quantity, seasonal variability
- Existing WWTP
- WWTP efficiency and operation
- Requirements after treatment
- Emerging pollutants

Environmental factors :
- Quality of receiving environment water, soils, biodiversity, …)
- Climate & climate change
- Environmental Impacts on water, air and soils
- Energy Consumption
- Greenhouse gas emission
- Topography an charasteristics of the site

MERCI DE VOTRE ATTENTION



Dusseldorf bank, 1956

This fairy tale will probably never come true

Life teaches you to be smart and save

! Then we will contribute to make it happen !

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