Assessment of wastewater treatment technologies including their water consumption impacts at endpoint level

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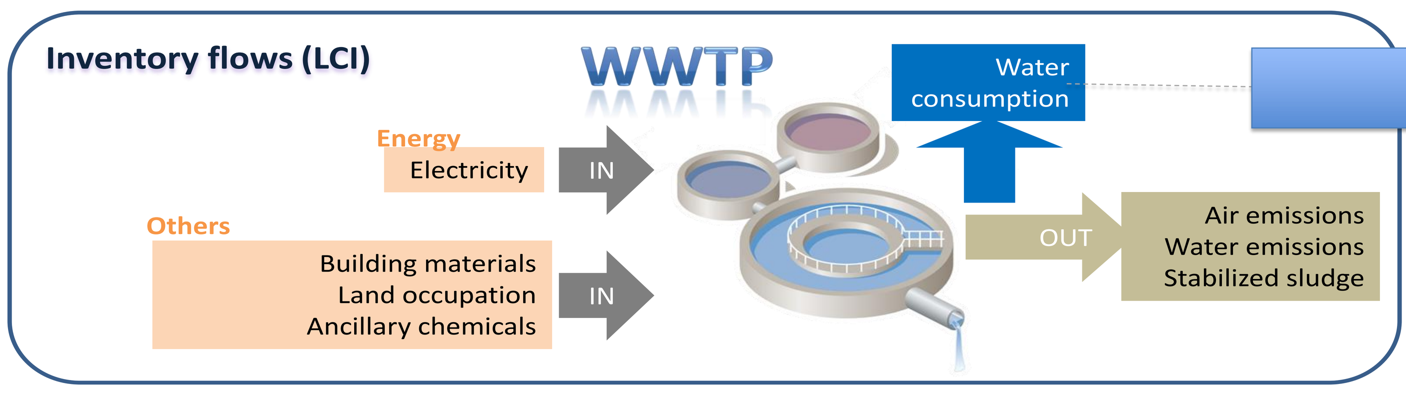
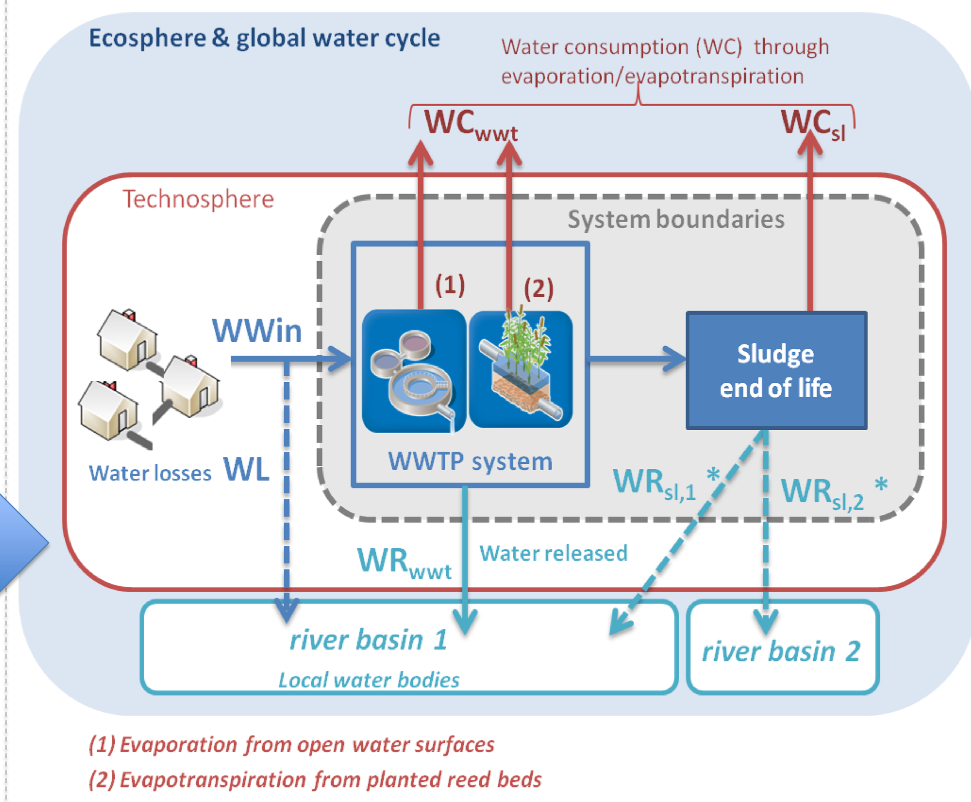
introduction

Life Cycle Assessment (LCA) offers a framework for the evaluation of the environmental sustainability of water systems. With recent methodological developments, it is now possible to assess both qualitative (environmental pollution) and quantitative (water deprivation) issues for wastewater treatment systems. This broader perspective allows for promising applications of LCA to WWT systems with the aim of optimizing the whole urban water cycle.



Water balance in a WWTP



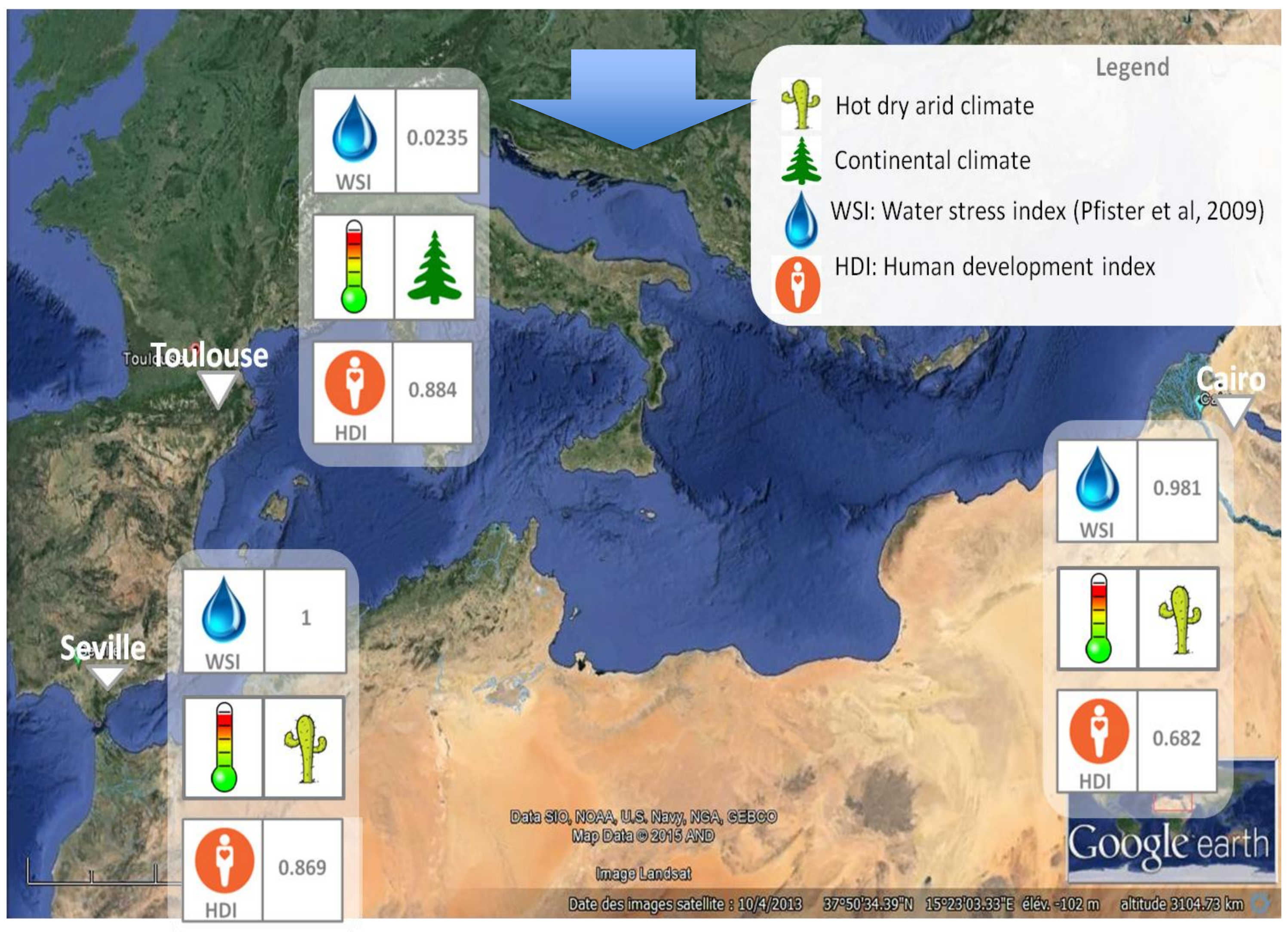
$$\sum WC = WW_{in} - \sum WR - WL$$

$$\sum WC = WC_{wwt} + WC_{sl}$$

- $WC_{wwt\,(1)}$, evaporation from open water surfaces in the activated sludge basins and polishing ponds
- $WC_{wwt\,(2)}$, evapotranspiration in the planted vertical reed bed filters
- WC_{sl}, bound water exported in sludge

materials & methods

3 contrasted geographical locations



3 WWT systems

- **AS** activated sludge
- **ASPol** activated sludge + polishing ponds
- **vRBF** vertical flow reedbed filter

Functional unit

For a WWT system: 1 PE.d^{-1} = 60 gBOD$_5$.d^{-1}

i.e. the treatment of a **daily load of biochemical oxygen demand for one person-equivalent**

LCI – Inventory of flows (materials, chemicals, energy inputs, air & water emissions and water consumption)

• Inventory of plant-level water consumption shows that compared to the activated sludge (AS), the other two systems consume 20-to-40 times more water. While there are 1.5-2.5-fold increases in WC between 2 contrasted locations (Toulouse and Seville) for a given technology.

LCIA - Impact assessment at the endpoint level (ReCiPe v1.07)

• Quantitative freshwater use in a specific river basin translates into impacts on human health, ecosystems and resources (Pfister et al., 2009)

• Freshwater deprivation based on yearly water stress indices (WSI), showing the severity of water scarcity in a given river basin :

0 (no stress) < WSI < 1 (extreme)

results & discussion

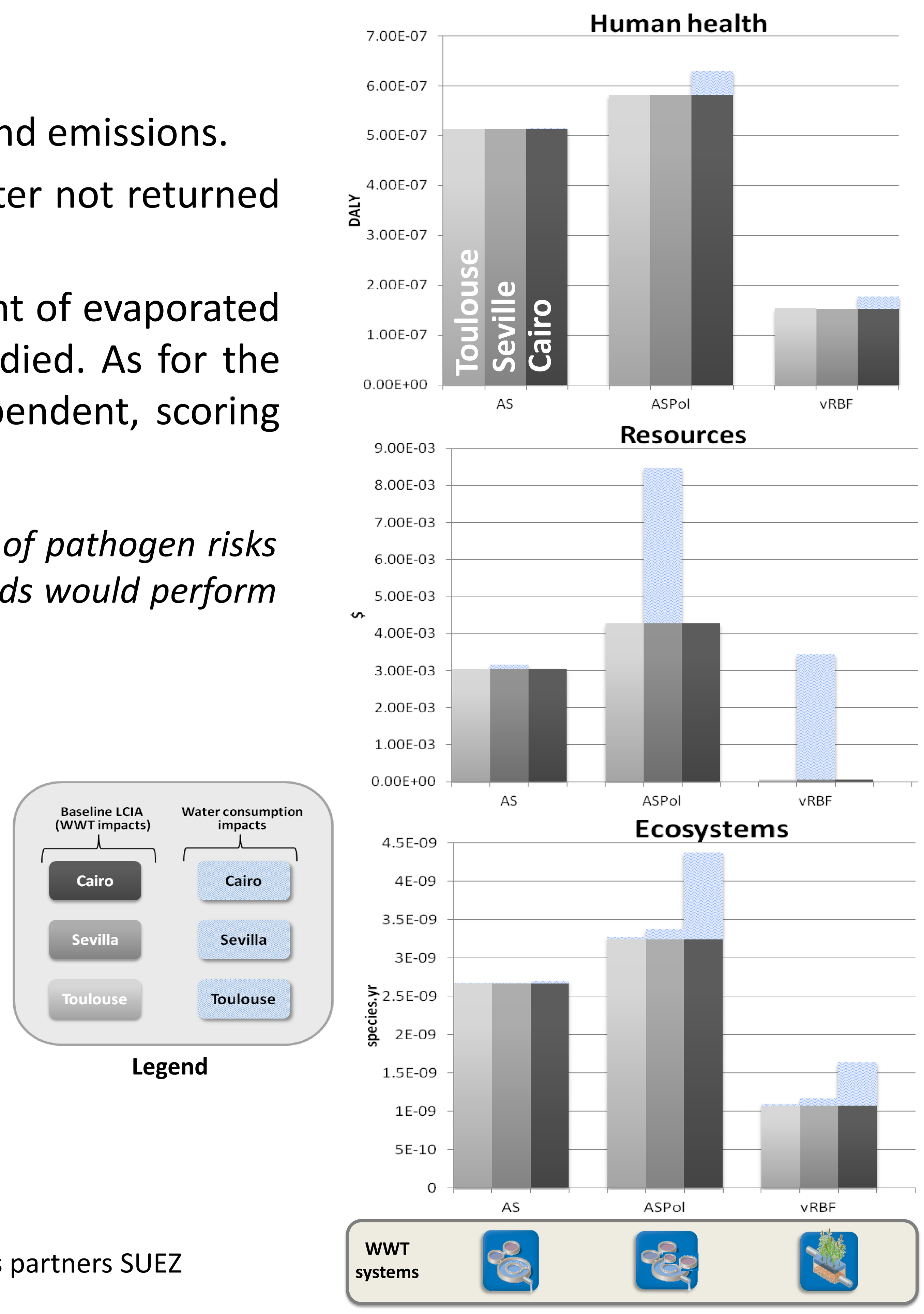
• "Baseline" damage score: in grayscale, is relative to WWTP infrastructure, operation and emissions.

• Water consumption (WC) damage score: in blue, is dependent on the amount of water not returned to the river basin, its local water scarcity and the country's human development.

• From a technological point of view, the activated sludge (AS) system with little amount of evaporated water has negligible WC impacts at the endpoint level, for all climatic conditions studied. As for the other 2 systems, the WC impacts on the endpoint categories are highly location-dependent, scoring high in water-scarce locations.

Biological Hazard

• *Pathogen abatement has not yet been accounted for in this study since the inclusion of pathogen risks to human health in LCIA methods is still underway. Activated sludge with polishing ponds would perform better than the other systems on this aspect.*



take home message

Consideration of water consumption-related impacts for WWT systems is important, especially for arid and semi-arid areas where water resources are scarce with a great potential for evaporation. With a better understanding of the water cycle within the technosphere, it will be possible for water managers to better mitigate water deprivation impacts at the local level, by selecting WWT technologies suitable for dry areas.

References
Pfister et al 2009 ES&T 43: 4098–104. Risch et al 2014 Water Res 57: 20–30.

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