Perspectives on water quality-induced water scarcity and its drivers

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What is water scarcity?
Rethinking water scarcity to include water quality

van Vliet et al. (2017)
*Nature Geoscience*

Quality matters for water scarcity

Michalle T.H. van Vliet, Martina Flörke and Yoshihide Wada

Quality requirements for water differ by intended use. Sustainable management of water for different uses will not only need to account for demand in water quantity, but also for water quality, nutrient levels and other pollutants.

Ma et al. (2020)
*Nature Communications*

Pollution exacerbates China’s water scarcity and its regional inequality

Ting Ma, Xiao Sun, Guangtuo Fu, Jim W. Hall, Yong Ni, Lihuan He, Jiawei Yi, Na Zhao, Yunyan Du, Tao Pei, Weiming Cheng, Ci Song, Chuanglin Fang, Chenghu Zhou

Pearl river

Water scarcity

- Irrigation - salinity
- Domestic - ammonia
- Energy - water temperature

water scarcity (water quality & quantity)
water scarcity (only quantity)
Water scarcity model framework

- water quantity
  - water availability

- water quality
  - water quality
  - water temperature
  - salinity (TDS)
  - organic pollution (BOD)
  - nutrients (TN, TP)

- sector water use

- sector water quality requirements

- desalination
- treated wastewater reuse


water supply

water demand

0.5 degree, monthly timestep
Increases in world’s population under severe water scarcity from 30% (only water quantity) to 40% (both water quantity and quality)

- Water scarcity driven by both water quantity and quality issues in hotspots regions

Critical water quality constituent for sectoral water use

van Vliet et al. (2021)
Irrigation ↔ freshwater salinization

Trends in surface water salinity 1980–2010

Thorslund et al. (2021), Nature Communications
DynQual: high-resolution surface water quality model

Approach:
1) Quantify pollutant loadings;
2) Route loadings through the stream network, accounting for decay processes;
3) Compute in-stream concentrations.

- 5 arcmin (10km) globally
- daily timestep → climate extremes (droughts, heatwaves)
Wastewater production, collection, treatment and reuse

(a) Production (million m$^3$ yr$^{-1}$)

(b) Collection (million m$^3$ yr$^{-1}$)

(c) Treatment (million m$^3$ yr$^{-1}$)

(d) Reuse (million m$^3$ yr$^{-1}$)

Jones et al (2021), Earth System Science Data
Expansion in desalination and treated wastewater reuse

**SDG 6.4:** reducing the number of people suffering from severe water scarcity

- Expansion in treated wastewater reuse for irrigation
- Expansion in desalination (inland/sea water) for domestic and industrial uses

Expansion in desalination and treated wastewater reuse

Treated waste water reuse expansion

1.4 → 4.0 billion m³/month

Desalination expansion

2.9 → 13.6 billion m³/month


- From resource perspective only
- Technical, socio-economic and environmental constraints and side-effects (energy demands, brine, costs) of technologies must be considered
Quality matters for water scarcity and its drivers

- **New water scarcity indicators** and **modelling framework** including impacts of **water quality** and **water technologies**
  - Regional hotspots of **water scarcity**, both in terms of **water quantity** and **quality**
  - Historical and future **trends in water quality** and **water scarcity** and their drivers

- **Expansions in water technologies to improve water quality** (SDG6.3) and **alleviate water scarcity** (SDG6.4)
  - Expanding **desalination** and **treated wastewater reuse** can strongly **reduce water scarcity**, especially in **hotspot regions** (e.g. eastern China and India).
  - The **side effects of these technologies** (e.g. brine, energy demand, cost) should be considered


Thank you!

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