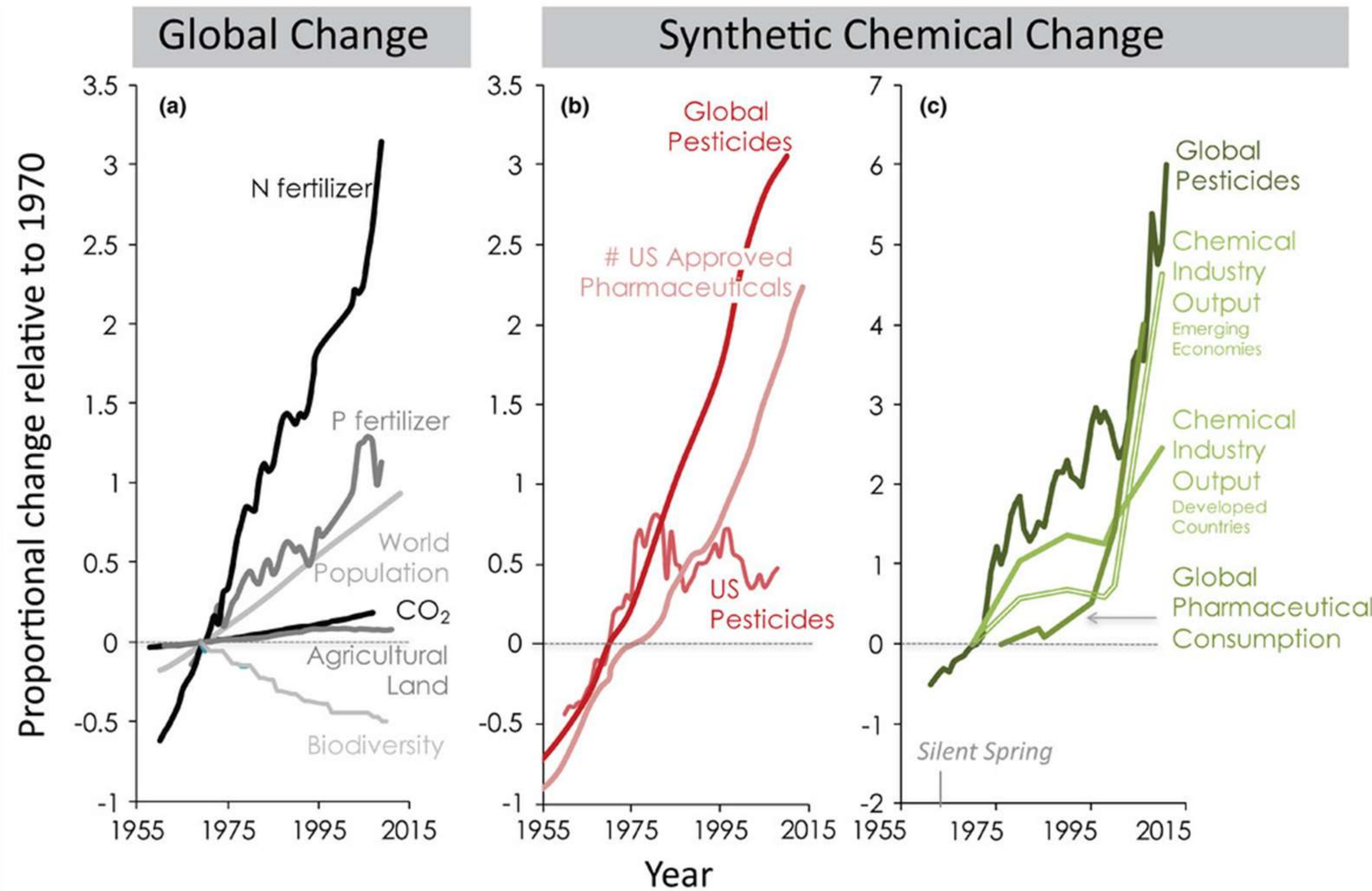
University of Amsterdam
Faculty of Science

Intentional Water Re-use in a non-toxic-free environment

Annemarie van Wezel

Growth in numbers and volumes of synthetic chemicals used outpace other factors of global change

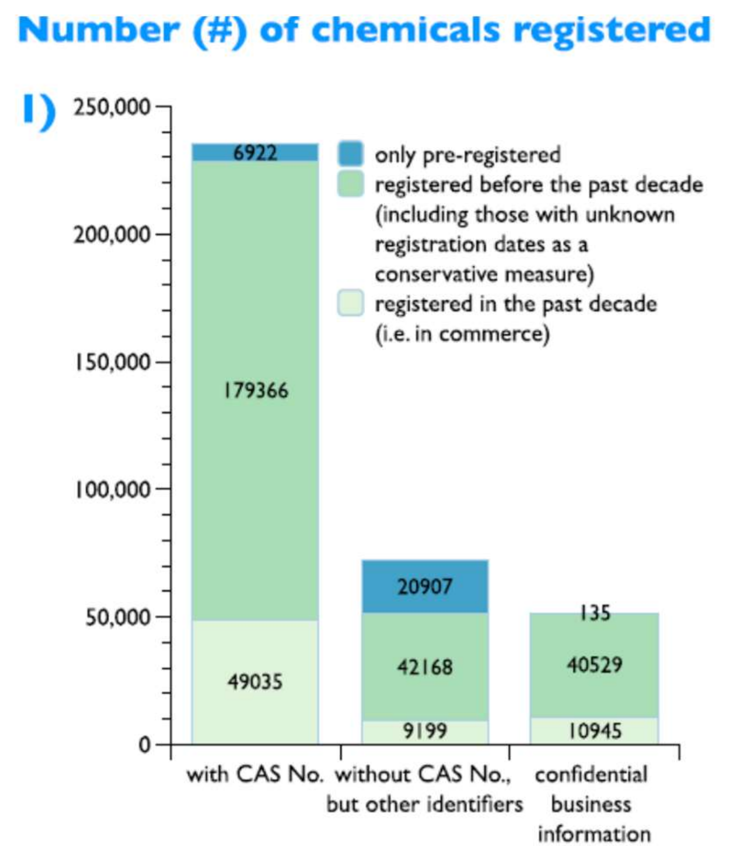


Bernhardt et al 2017 Front Ecol Environ

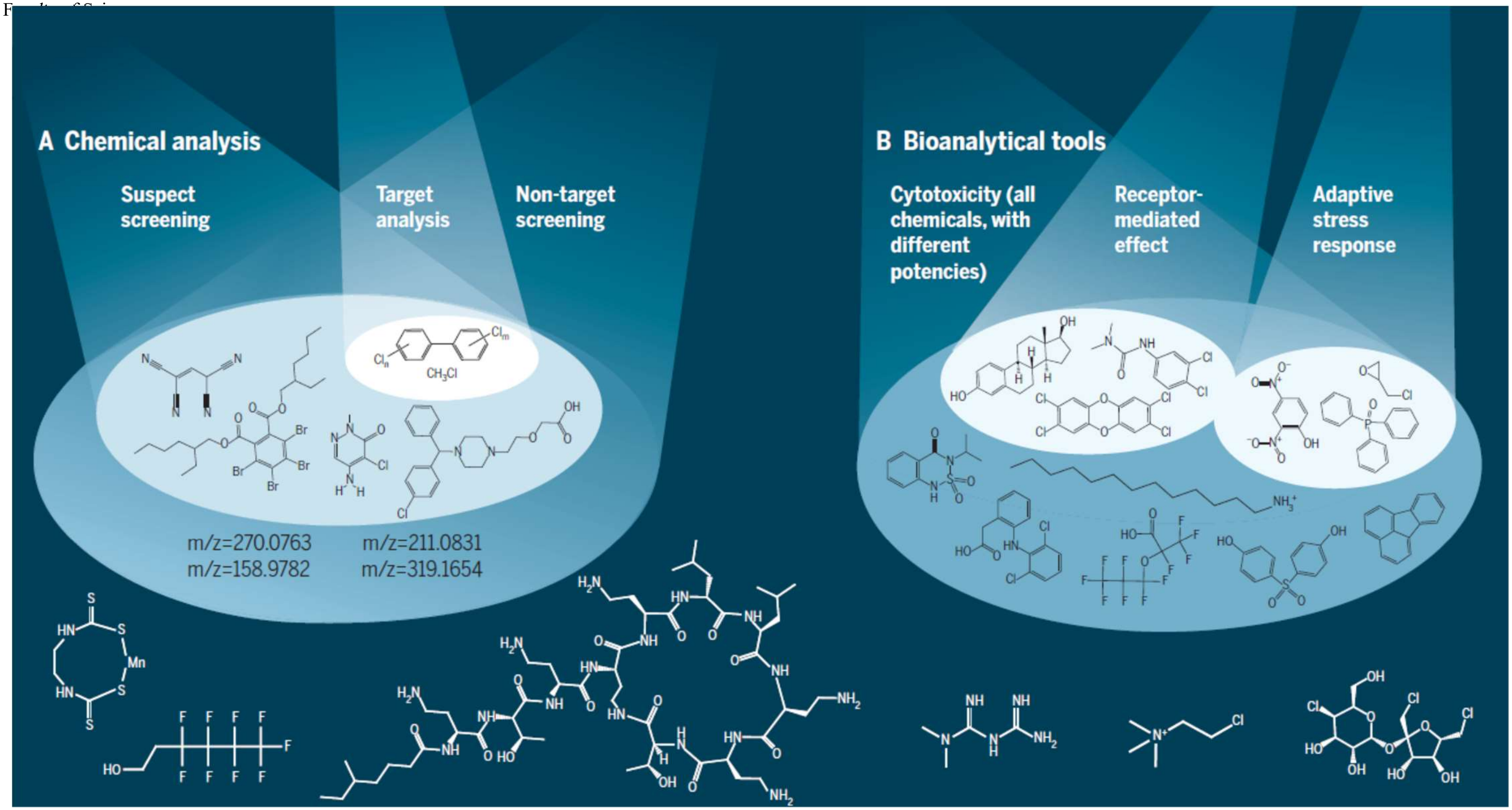
UNIVERSITY OF AMSTERDAM
Faculty of Science

Global Understanding of Chemical Pollution

Over 350 000 chemicals and mixtures registered for production and use worldwide
Identities of many chemicals publicly unknown, claimed as confidential (over 50 000) or ambiguously described (up to 70 000)



Wang et al 2020



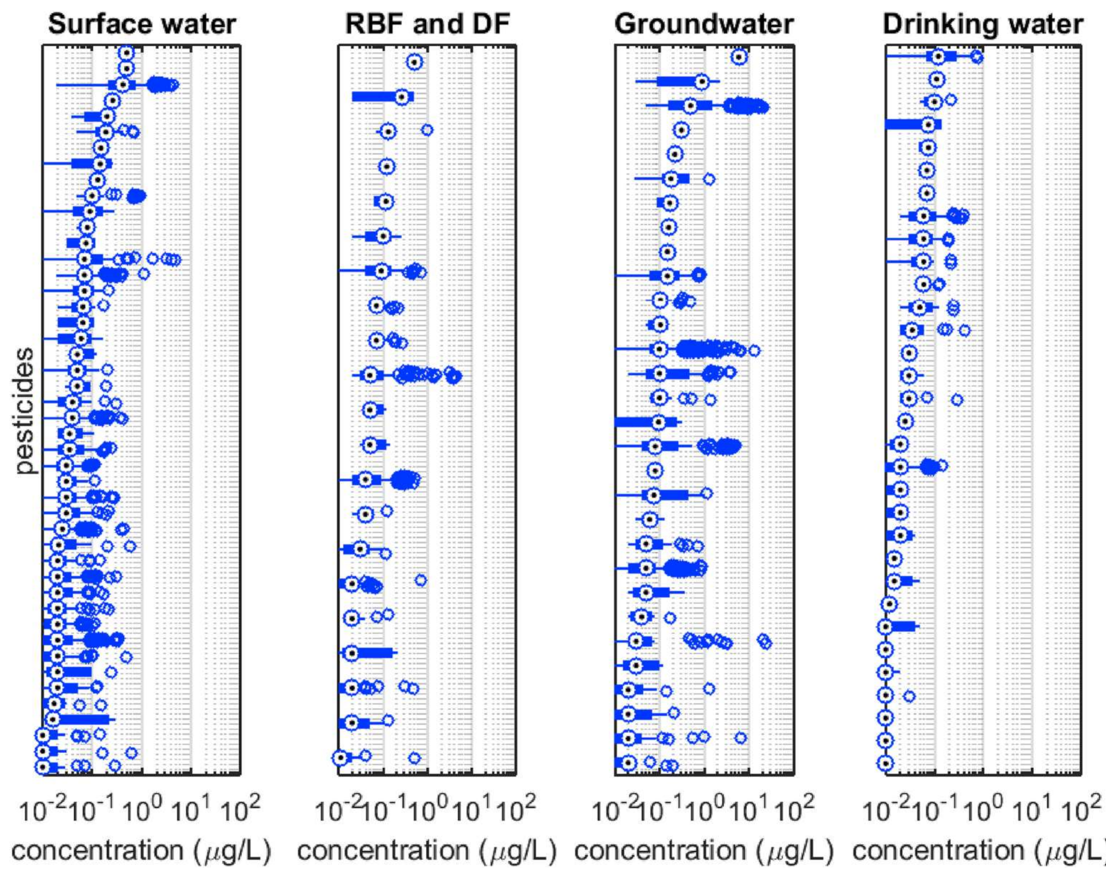
Escher et al 2020

Example target monitoring; Pesticide occurrence in sources for drinking water

Data 2010-2014, The Netherlands, 63/408 pesticides and 6/52 metabolites were prioritized.

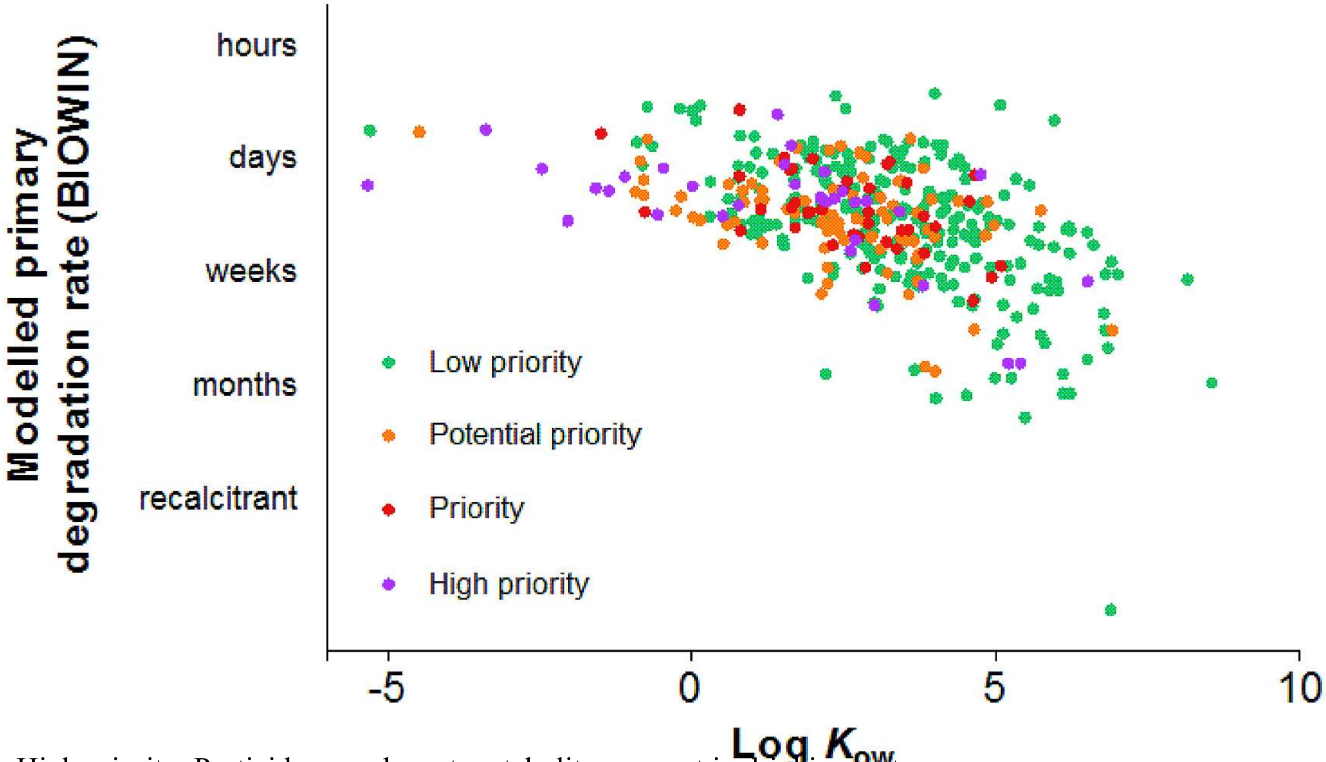
Vast majority not detected or only in low concentrations

In 67% of sources pesticides/metabolites detected, in 31% of sources WFD water quality standards exceeded



Sjerps et al 2019 Chemosphere

Mobile and persistent pesticides more likely to be classified as (high) priority pesticides

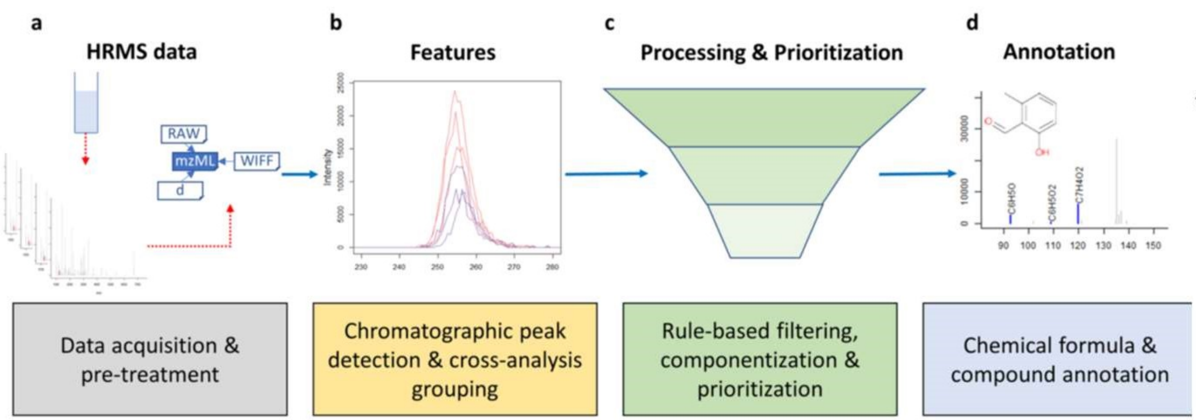


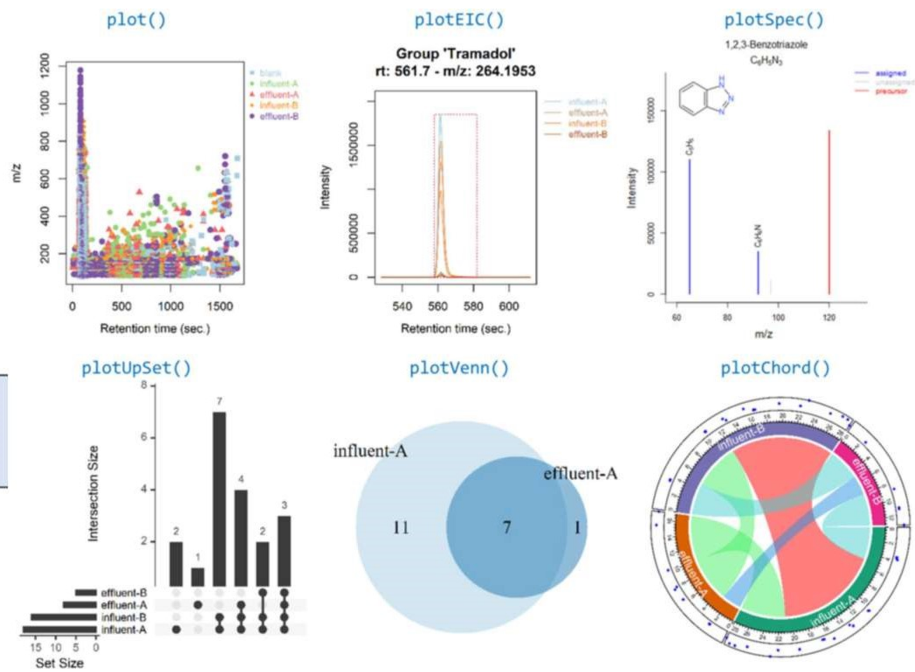
High priority: Pesticides or relevant metabolites present in drinking water
Priority: Pesticides or relevant metabolites present in drinking water sources >0.1 µg/L
Potential priority: Pesticides or relevant metabolites present drinking water sources > 0.1 < 0.1 µg/L
Low priority: Pesticides or relevant metabolites do not exceed 0.01 µg/L

Sjerps et al 2019

UNIVERSITY OF AMSTERDAM
Faculty of Science

patRoon: Open-Source Software Platform for Environmental Non-Target Studies

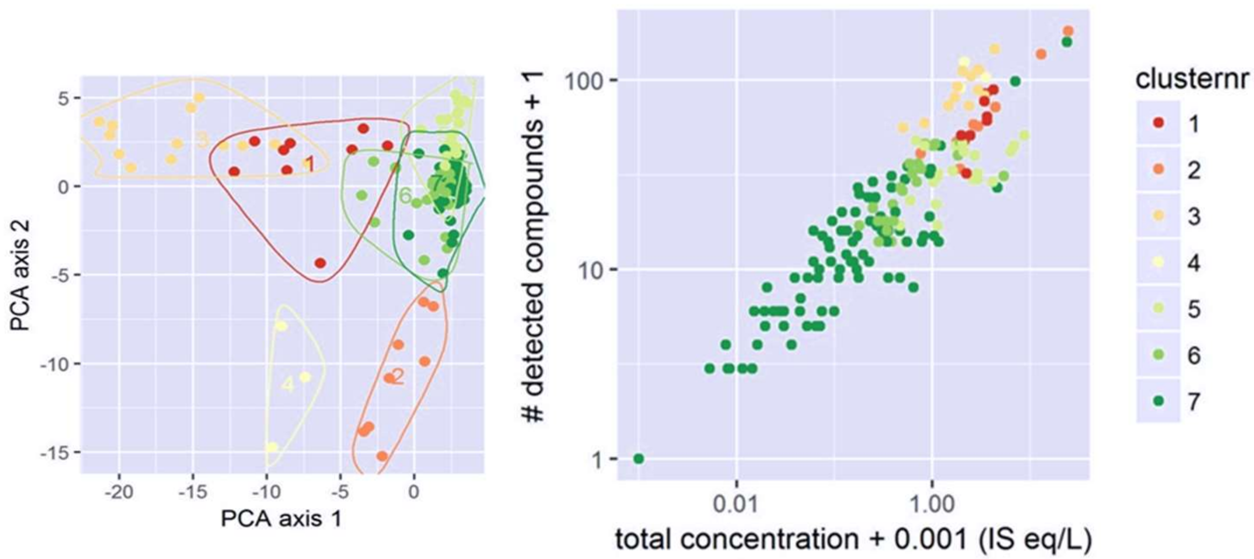




Helmus et al 21

Risk based monitoring

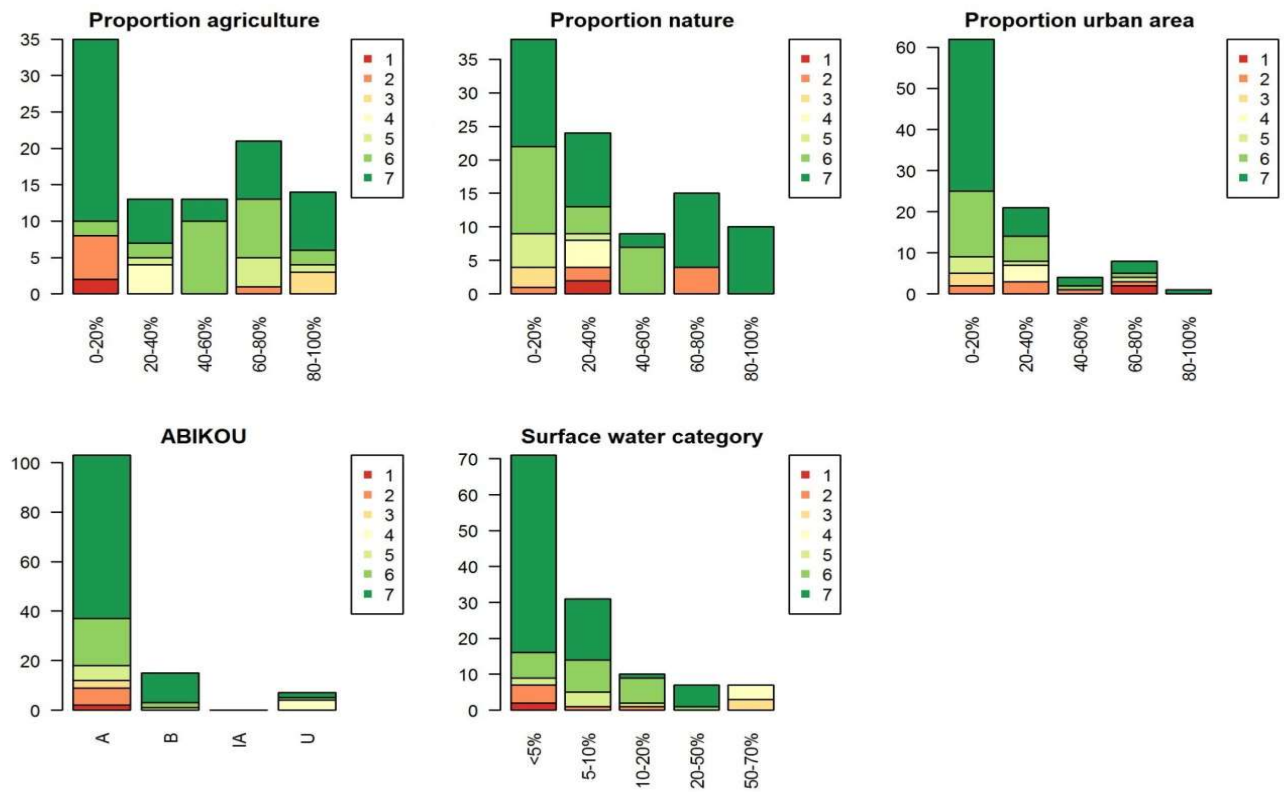
- 108 source waters clustered on both target as suspects
- Half relatively non-vulnerable
- 153/731 target chemicals detected
- 1,398/12,294 occurring HRMS features match to 3,590 suspects
- Suspects prioritized for further identity confirmation based on semi-quantitative occurrence, frequencies and info on toxicy
- Once confirmed and assessed as relevant, the suspects could be added to target monitoring



Sjerps et al 2021

University of Amsterdam
Faculty of Science

Source waters with higher number of chemicals relate to high levels of infiltrated surface water

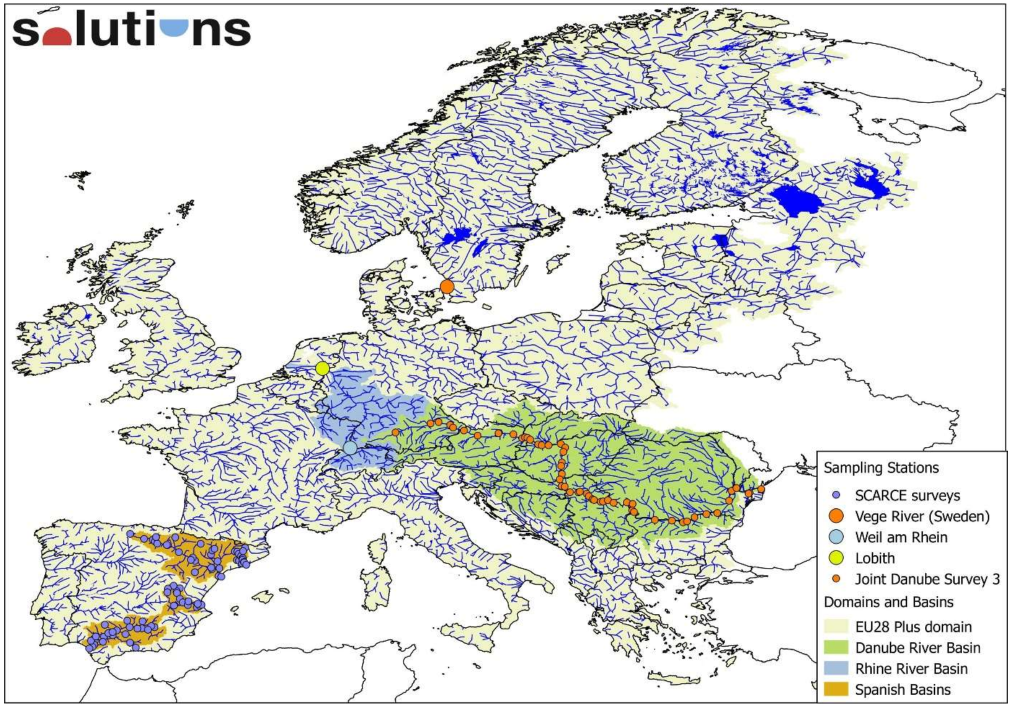


Sjerps et al 2021

UNIVERSITY OF AMSTERDAM
Faculty of Science

Computational material flow analysis for thousands of CECs in European waters

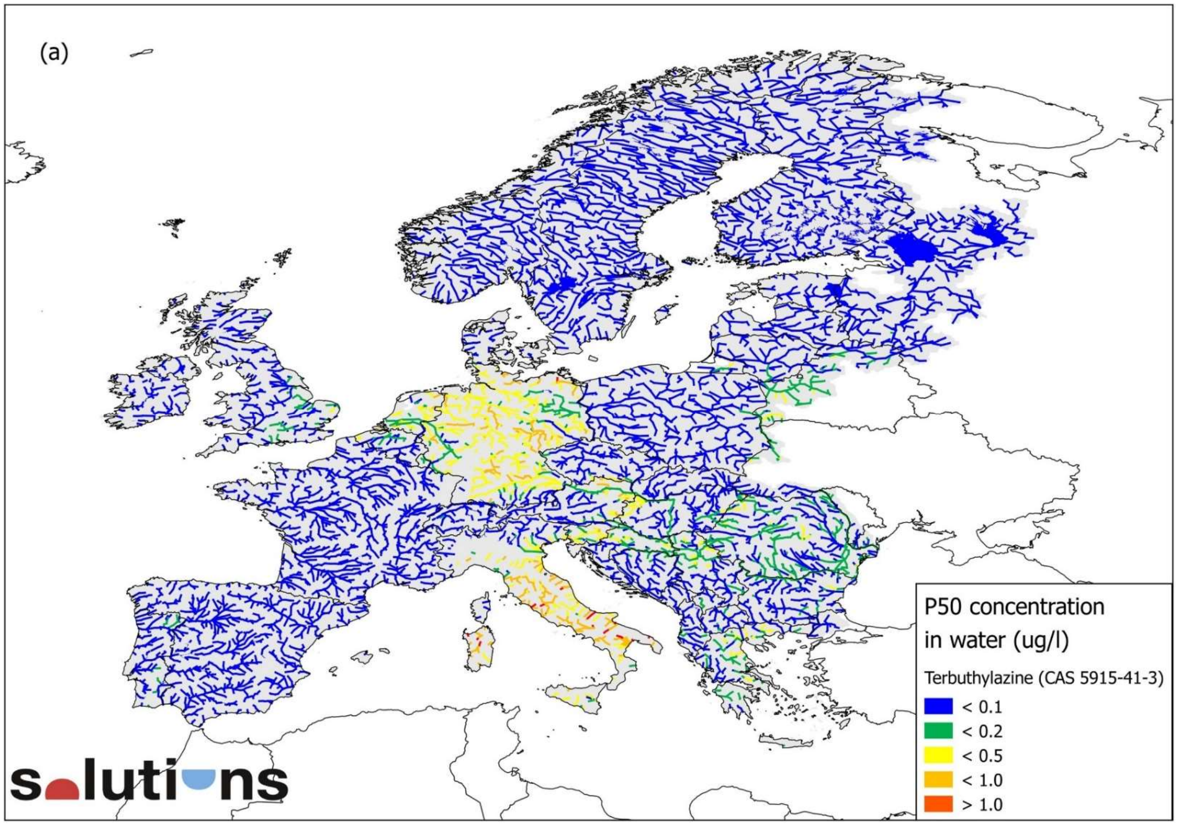
- Europe-wide hydrology model E-Hype
- “Locator” values;
  - REACH chemicals and pharmaceuticals - Pop x GDP-PPP x WF
  - Pesticides - agriculture land use, 7-day application periods during the relevant season
- STREAM-EU dynamic mass balance model spatially and temporally resolved
- Substance properties
- Estimated emission for 621 pharmaceuticals, 408 pesticides and 4159 REACH registered organic chemicals
- Comparison to monitoring data



Van Gils et al 2020

UNIVERSITY OF AMSTERDAM
Faculty of Science

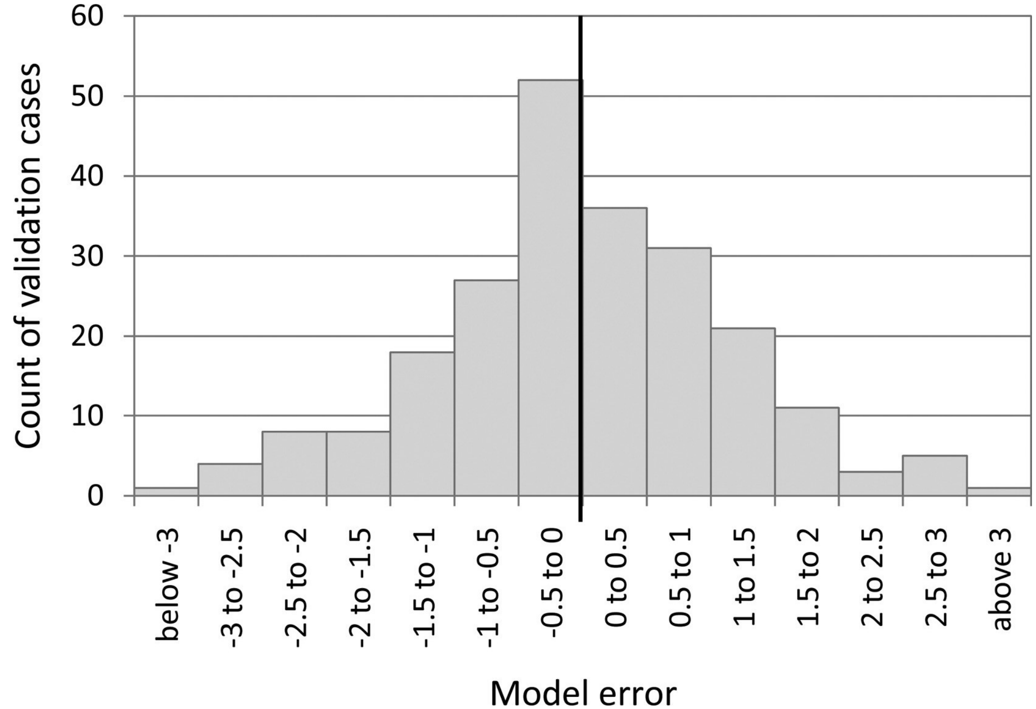
Prediction per compound per basin



Van Gils et al 2020

CMFA accuracy

Model outputs could be compared to measured concentrations for 226 substance/basin combinations
Average error is effectively zero (-0.01), standard deviation is 1.20.
In 65% of cases error is below one order of magnitude, in 90% of cases the error is below two orders of magnitude

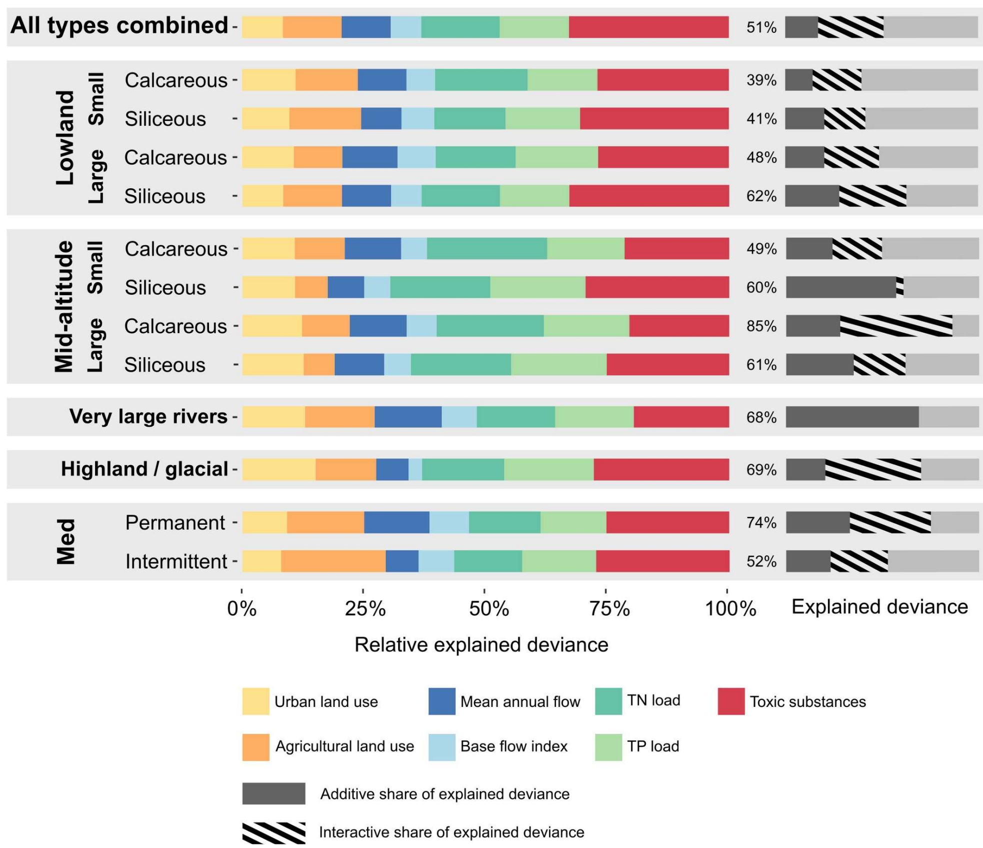


Van Gils et al 2020

Current chemical legislation is not sufficiently protective

- Chemicals increasingly detected in EU surface and drinking waters & affects biodiversity
- Over 50% of EU water bodies in poor ecological condition
- Future societal developments will result in higher concentrations and diversity of chemicals in the environment
- 90% of EU citizens worry about the impact of chemicals on the environment

→ increasing pressure to make EU chemicals regulation more stringent



msPAF-EC50 highest share in relative explained deviance; Lemm et al Glob Change Biol '20

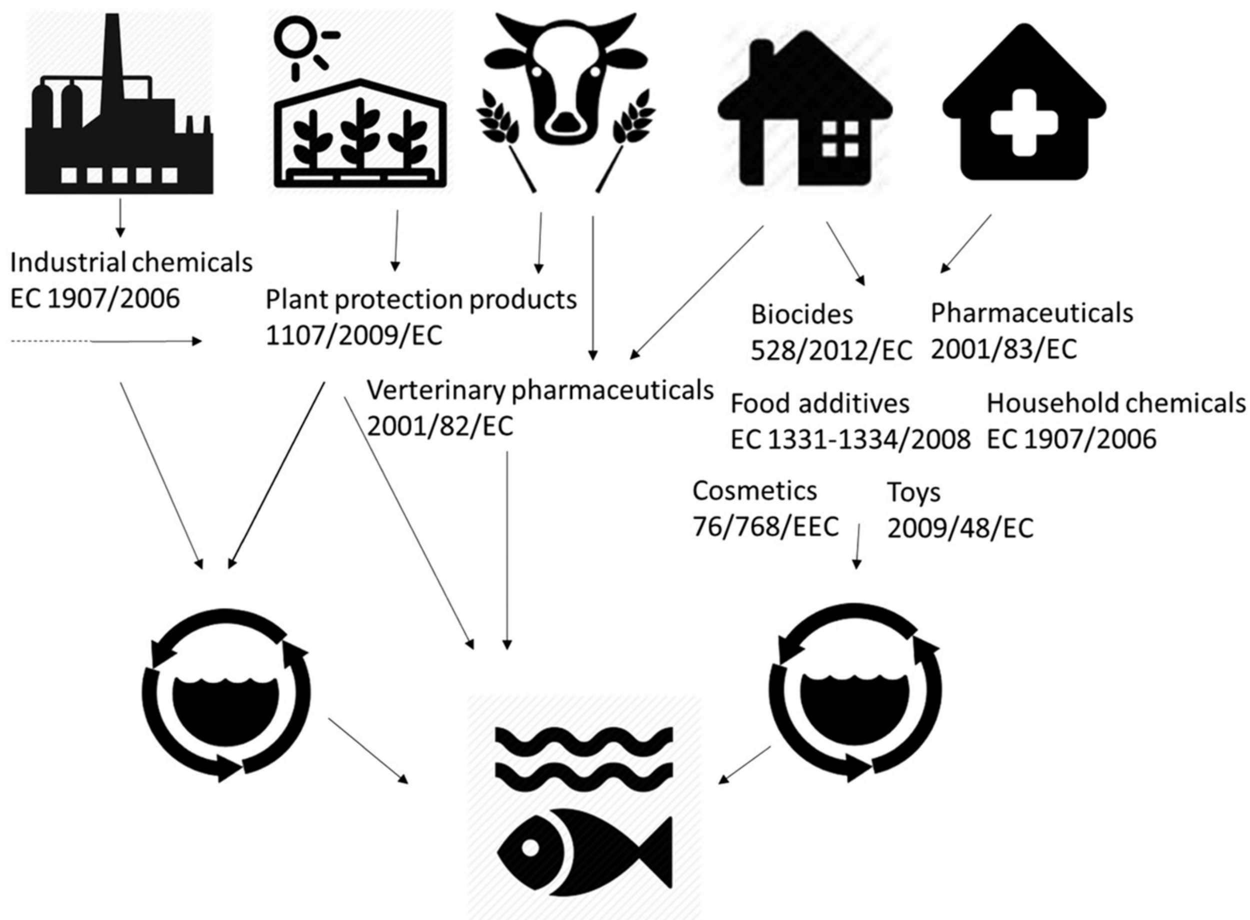
UNIVERSITY OF AMSTERDAM
Faculty of Science

As part of EUGD; Chemicals Strategy for Sustainability (CSS)

- Chemicals Strategy for Sustainability (CSS, oct '20)
- First regional framework addressing chemical pollution in a holistic manner
- Covers complete life-cycle of a chemical, including design and remediation options

UNIVERSITY OF AMSTERDAM
Faculty of Science

Current (fragmented) EU registration/authorization frameworks



Van Wezel et al 2017

UNIVERSITY OF AMSTERDAM
Faculty of Science

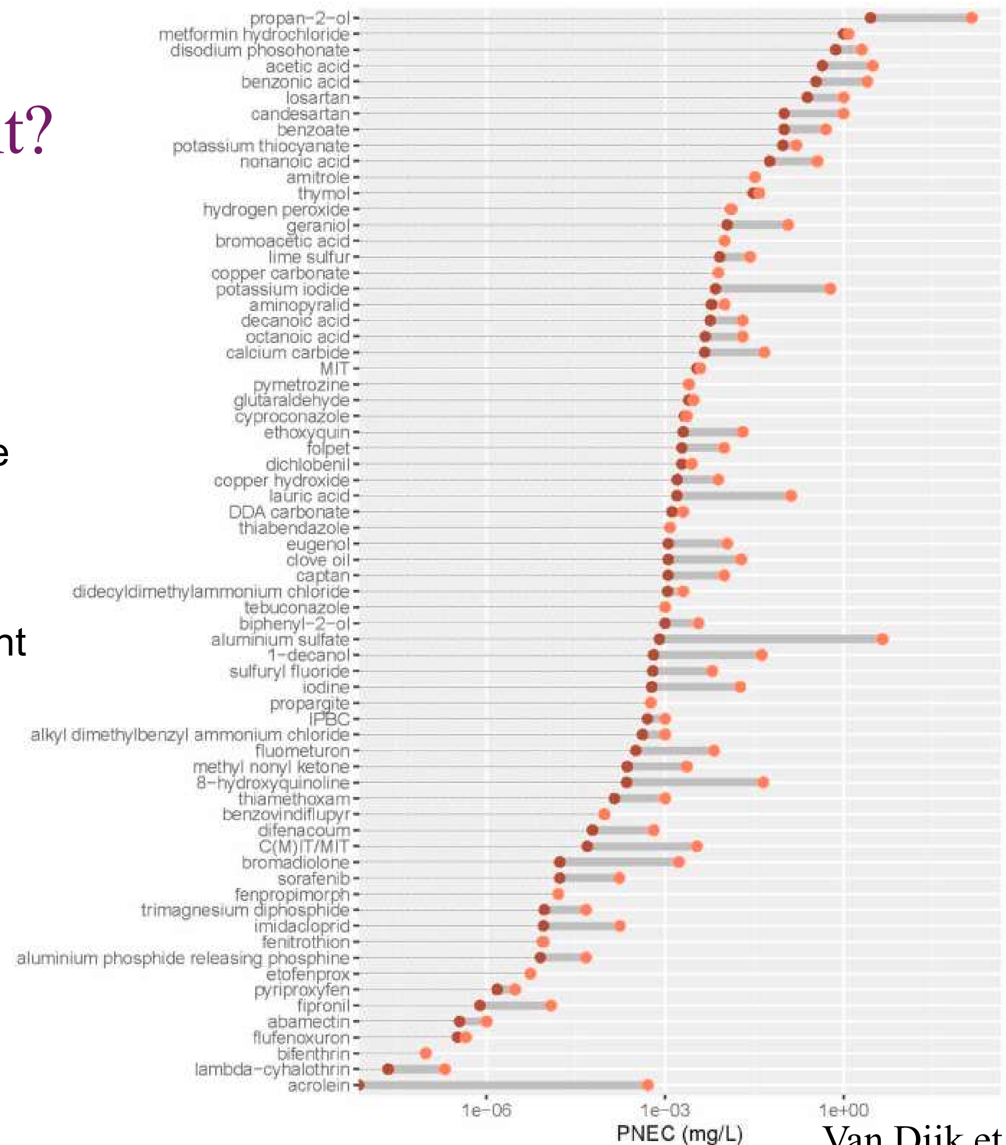
One Substance – One Assessment?

Chemicals can be registered under multiple frameworks

Chemicals not approved under one framework can be allowed under others

Similar function of frameworks, but important differences in risk assessment strategies → incoherent assessments

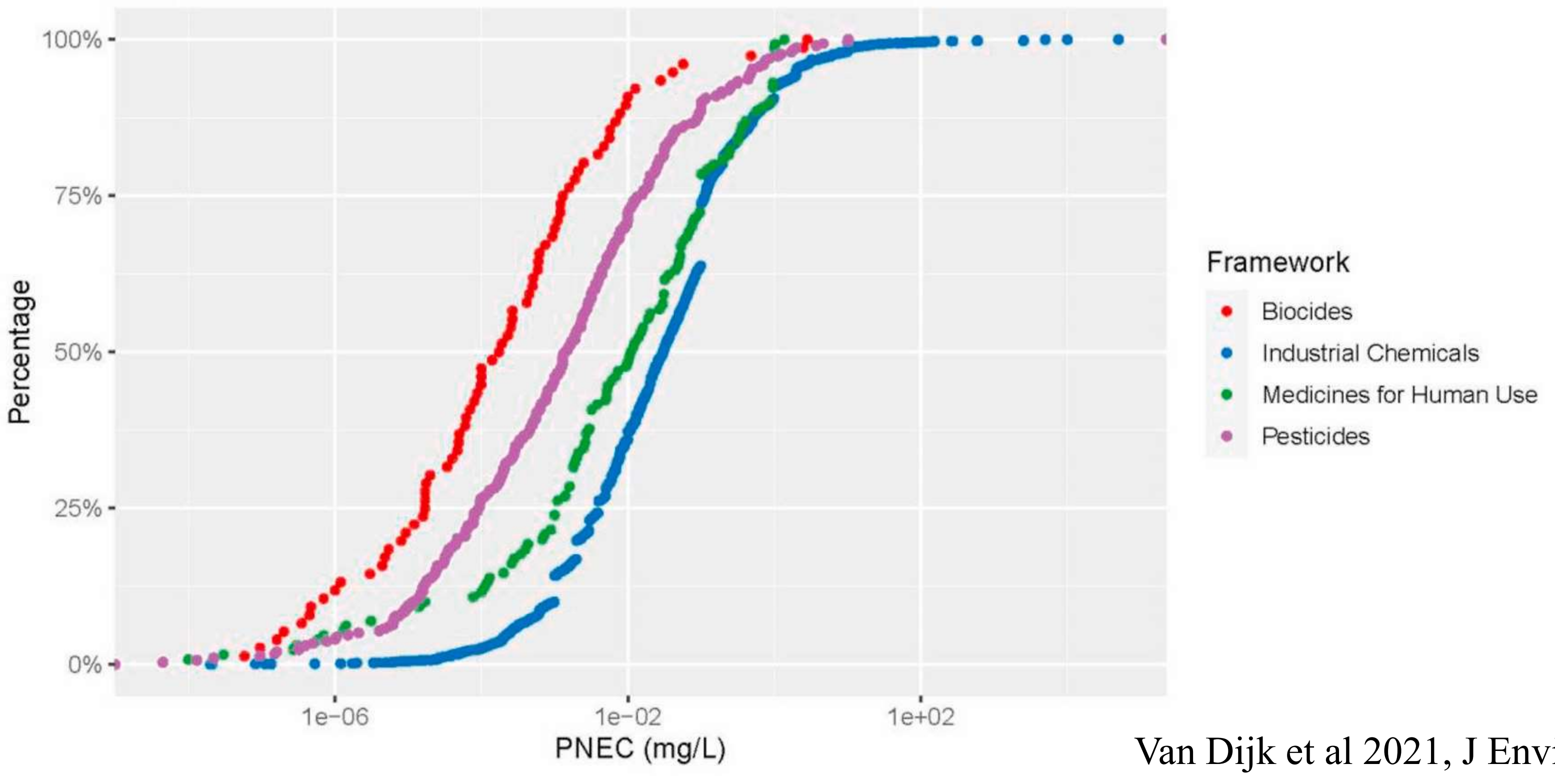
PNEC values for 65 substances registered under multiple frameworks can differ up to a factor of 5625, a median difference of 3.6



Van Dijk et al 2021

Comparing ecotoxicity

Comparing PNECs; biocides on average are the most hazardous group of chemicals

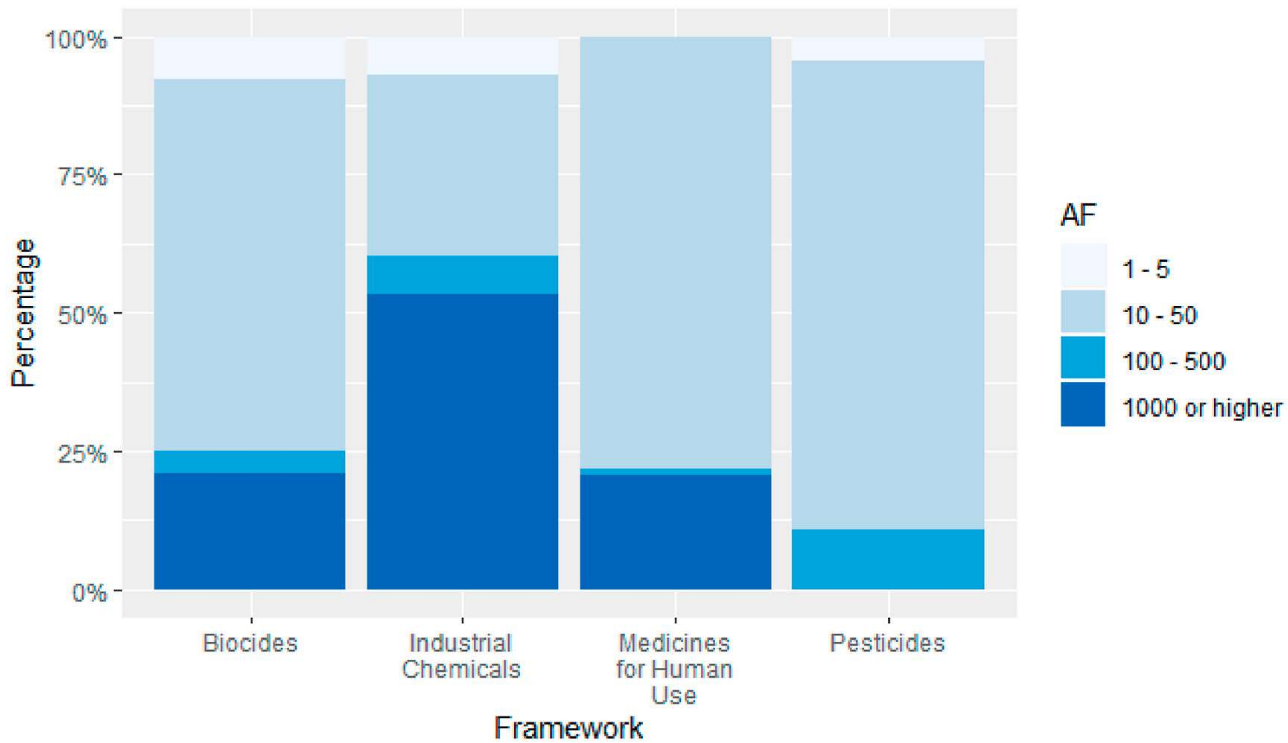


Van Dijk et al 2021, J Environ Man

University of Amsterdam
Faculty of Science

Use of assessment factors

Applied on most sensitive endpoint, differ between the frameworks
Little empirical evidence, debated if AFs sufficiently cover extrapolations (acute to chronic, lab to environment) and mixture effects
→ additional uncertainties to environmentally safe concentration



Van Dijk et al 2021

Towards a successful move toa OS-OA

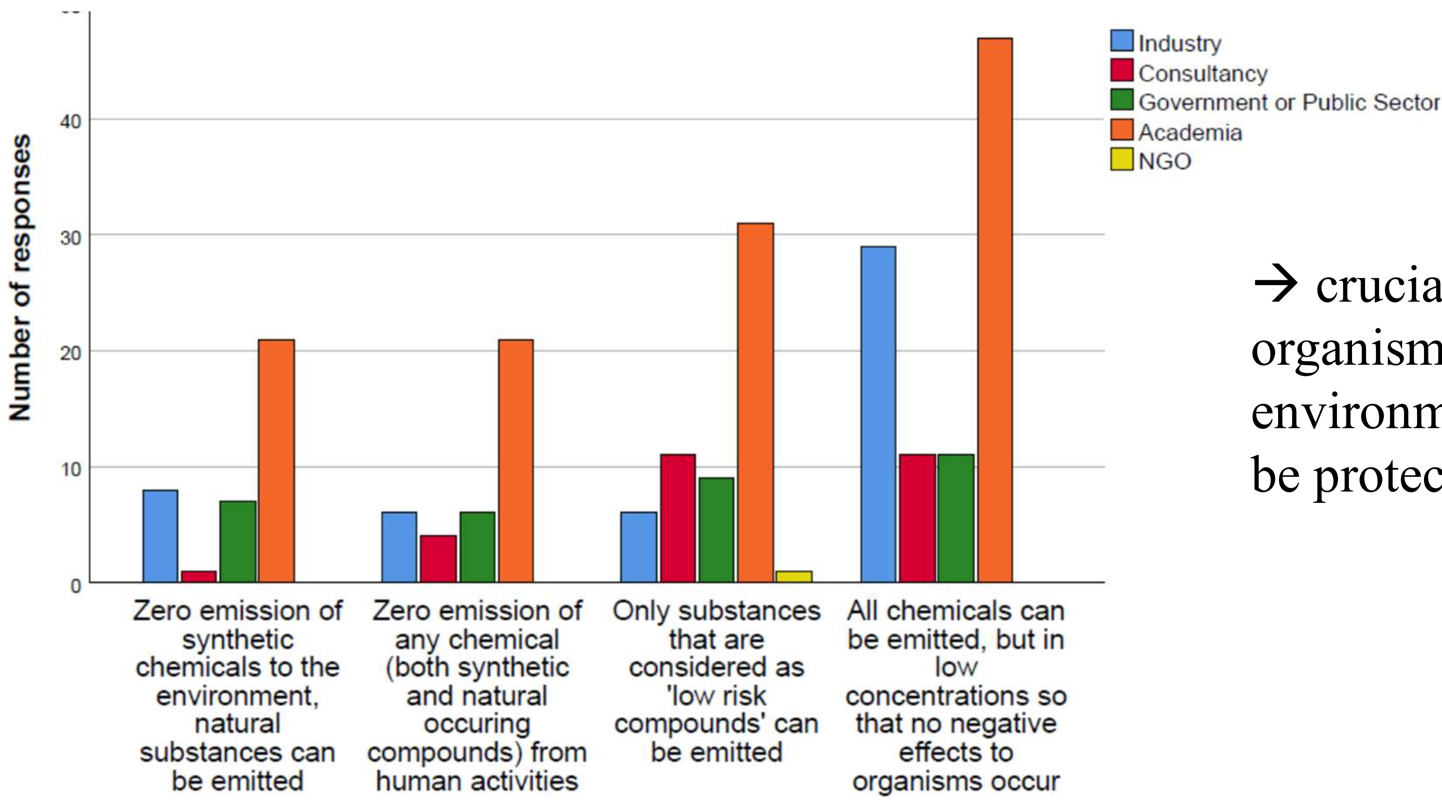
- Harmonise environmental protection goals and risk assessment strategies, no exemptions for environmental risk assessments, regular re-evaluation
- Emission, use and production data publicly available and shared; before critical PEC/PNEC ratio reached prioritize most essential uses/sectors
- Align criteria used to classify problematic substances (SVHC, CfS, SoC)

→ streamlining of RAs is not only key to achieve coherent and more transparent outcomes but is also essential for functioning of the EU single market

Van Dijk et al 2021

A toxic-free environment

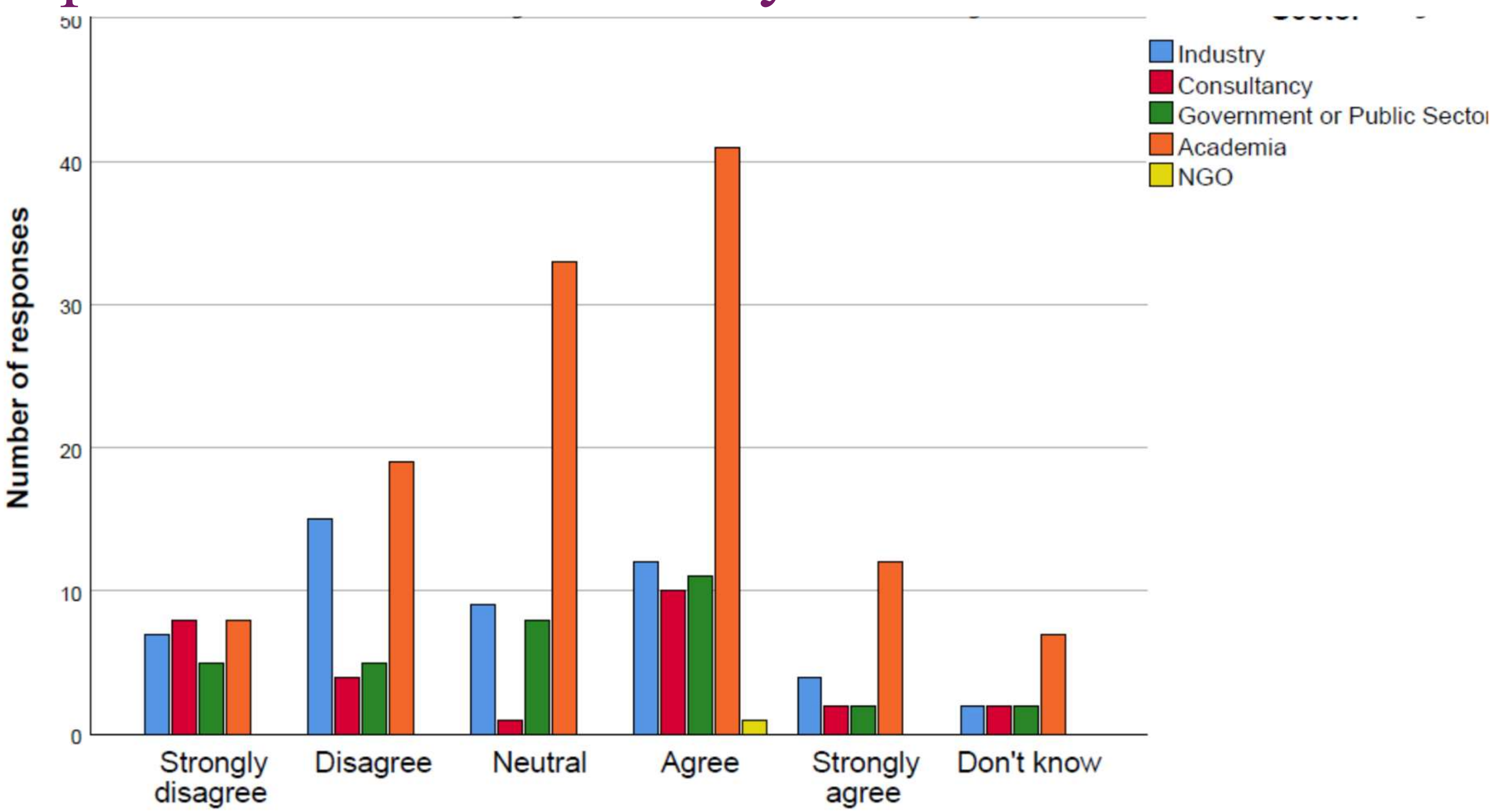
CSS; where chemicals are produced and used in a way that maximises their contribution to society including achieving the green and digital transition, while avoiding harm to the planet and to current and future generations



→ crucial to define what organisms, functions and environmental effects are to be protected

Van Dijk et al '21 IAEM

Optimism on achievability a toxic-free environment



Van Dijk et al ‘21 IAEM

Different disciplines needed for **responsible water re-use**

Current practice: uncontrolled, unintentional, and indirect reuse, including related risks and inefficiency

Dingemans et al '20

Overview of existing and developing legislative frameworks of water reuse for industry, agriculture, or drinking water.

ISO Guidelines 20426, 20468, 20469 (2018)
WHO Guidelines for the safe use of wastewater, excreta and greywater (2006, revision ongoing)
WHO's Guidance of potable reuse (2017)
USEPA Guidelines for water reuse (2012)
US and California's Title 22 (updated in 2015)
Colorado incorporated water reuse in regulatory framework (no other states or US federal rules)
US federal regulation Food Safety Modernisation Act (2017) (relevant for crop irrigation in Latin America)
Australian Guidelines for Water Recycling (2006)
Oman national guidelines for water reuse
National standards of EU Member States (e.g. Spain Royal Decree 1620/2007)
EU Minimum requirements for water reuse in agriculture (legislation in consultation phase)
United Arab Emirates develops legal framework for water reuse (feasibility studies ongoing)
Saudi Arabia restructured water-related organizations and ministries to clarify responsibilities

Dingemans et al '20

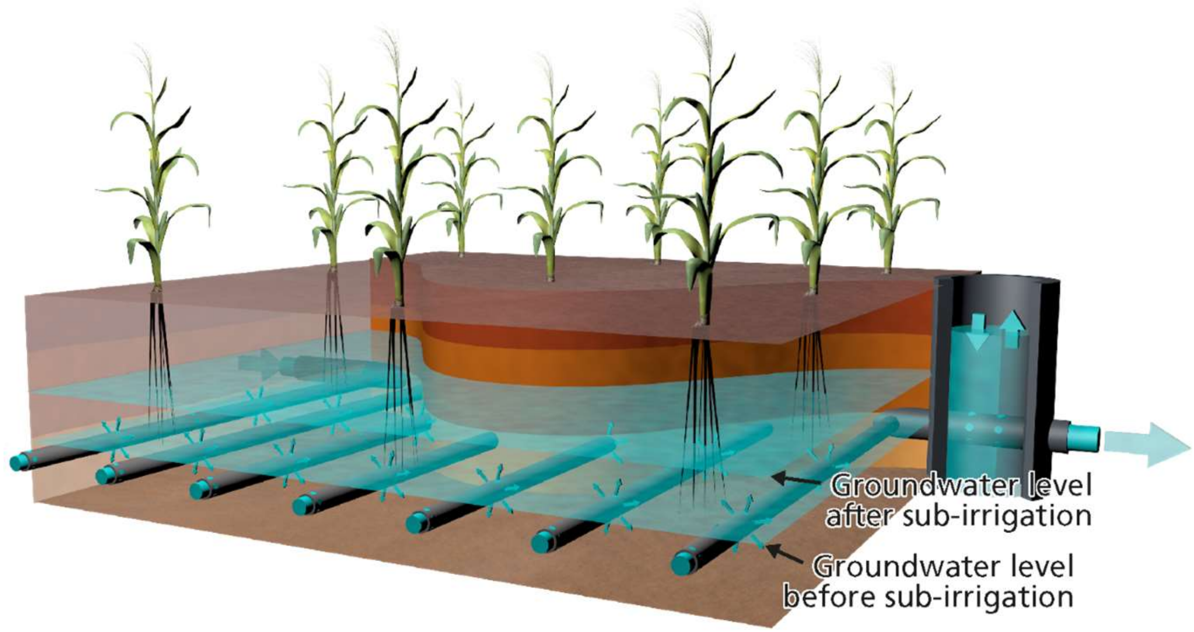
University of Amsterdam
Faculty of Science

Schematic overview of Sub Surface Irrigation systems

Dual purpose: Supply water to crops & soil as filter

Only project in Netherlands direct domestic wastewater reuse in agriculture

Intentional vs *de facto*/unintentional



Narain-Ford et al. 2020

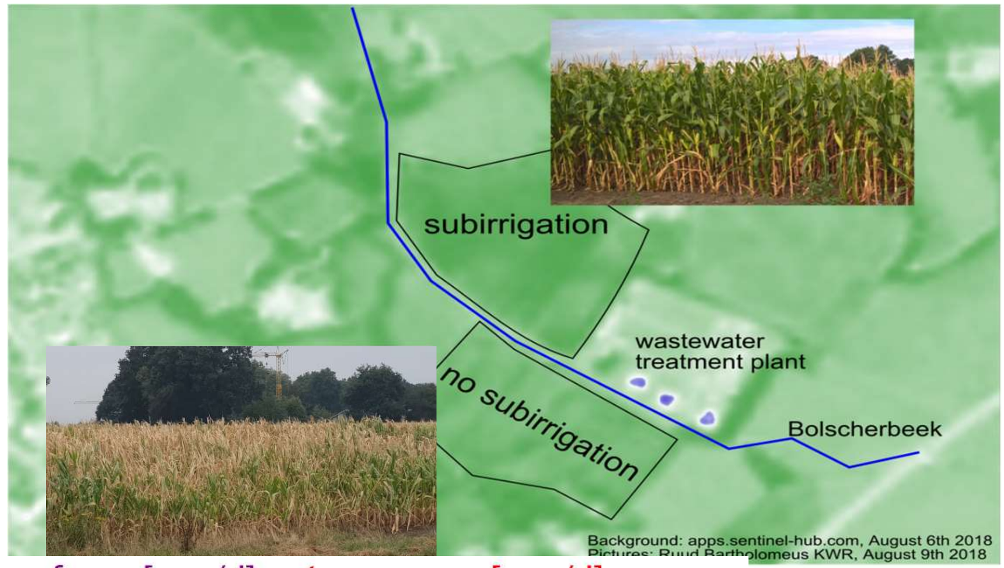
Fate of CEC in various irigation systems

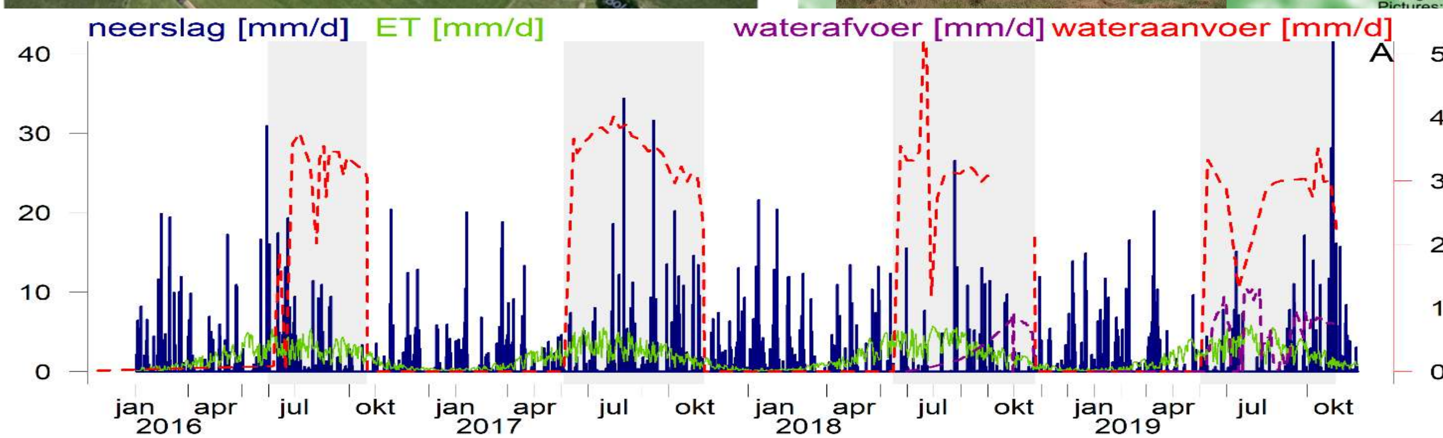
	Irrigation systems			
	Sprinkler	Drip		Sub-surface
		Surface	Sub-surface	
Sorption	×	××		×××
Photolysis	×××	×××	××	*Insignificant*
(Bio)transformation	×	×	××	×××
Run-off	×××	*Insignificant*		*Insignificant*
Volatilization	×××	×××	××	*Insignificant*
Crop uptake	×××	×××		××

(Christou et al., 2019a; Gupta and Madramootoo, 2017; Kibuye et al., 2019; Pepper and Gerba, 2018)

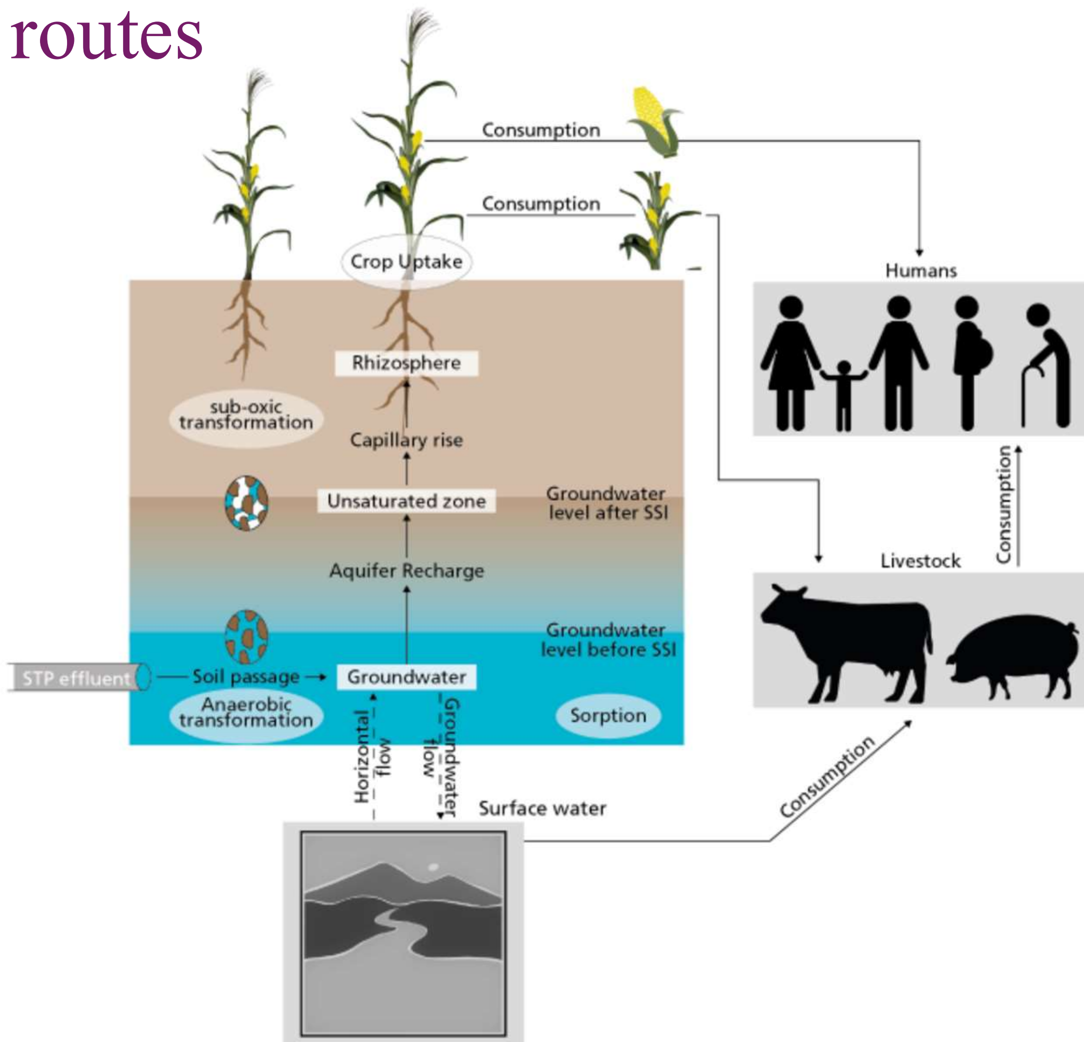
Narain-Ford et al. 2020

Real scale SSI with STP effluent. Haaksbergen





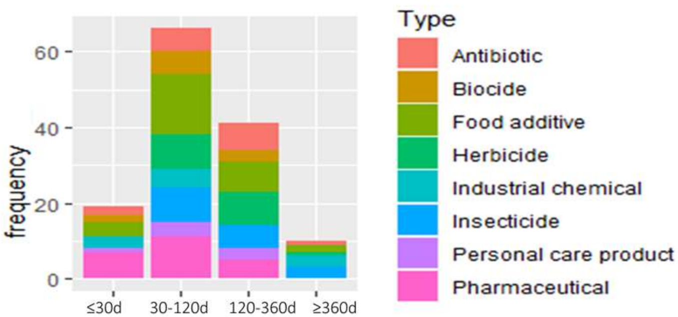
Possible exposure routes

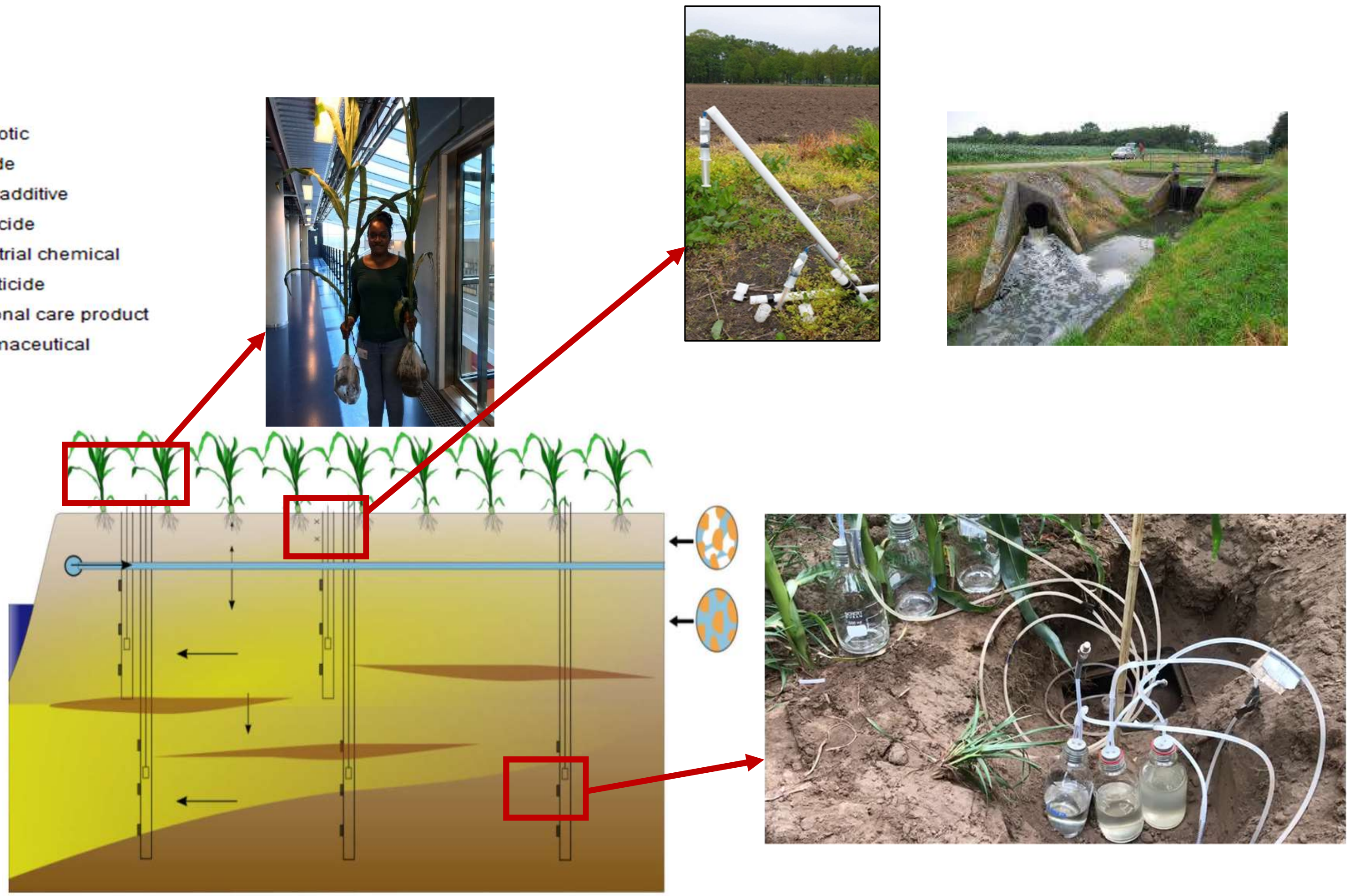


Narain-Ford et al. 2020

University of Amsterdam
Faculty of Science

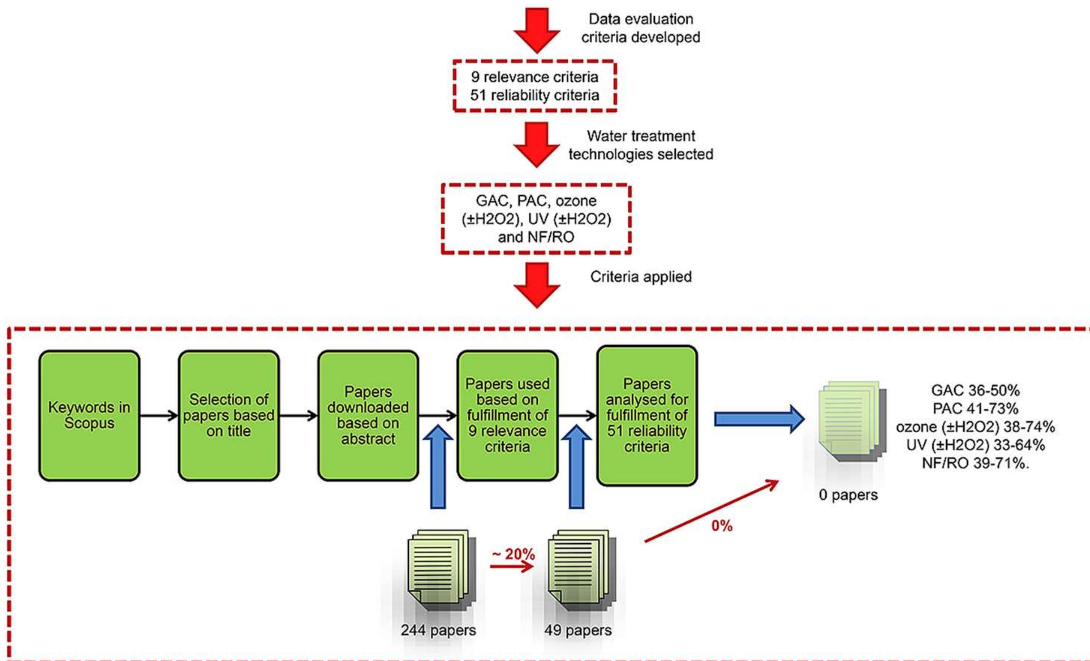
Samples





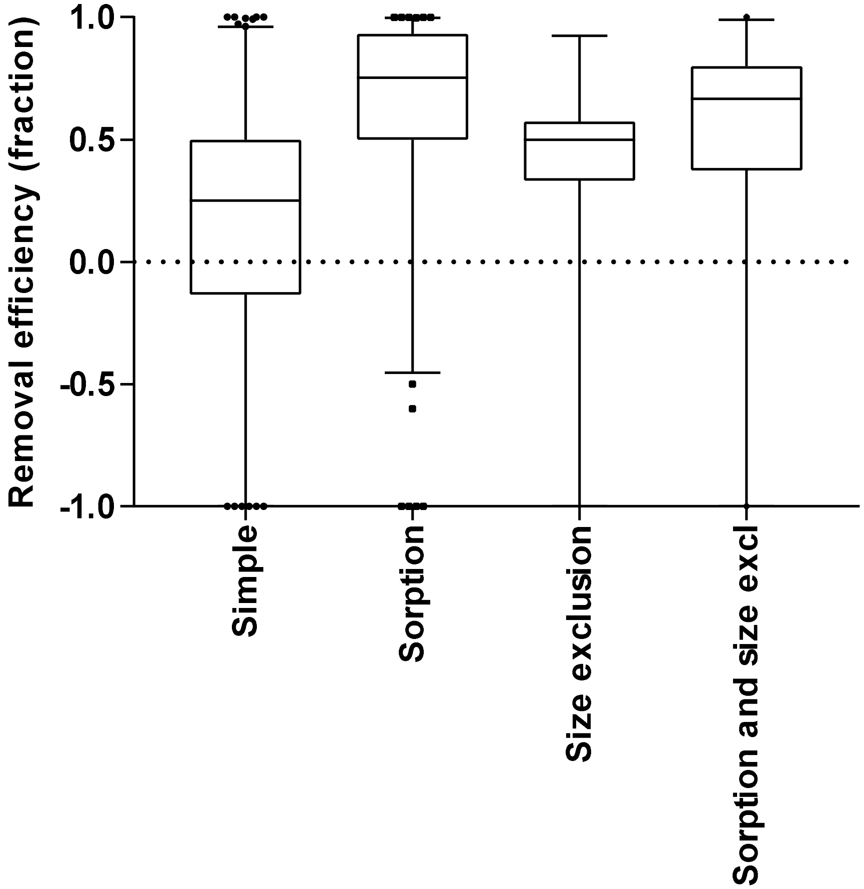
Relevance and reliability criteria for water treatment removal efficiencies

- •9 relevance criteria and 51 reliability criteria
- •Applied to 244 treatment technology studies, 49 papers fulfilled the relevance criteria
- •Reliability criteria applied to the 49 remaining papers.
- •Findings clearly demonstrates the need for a more uniform approach.



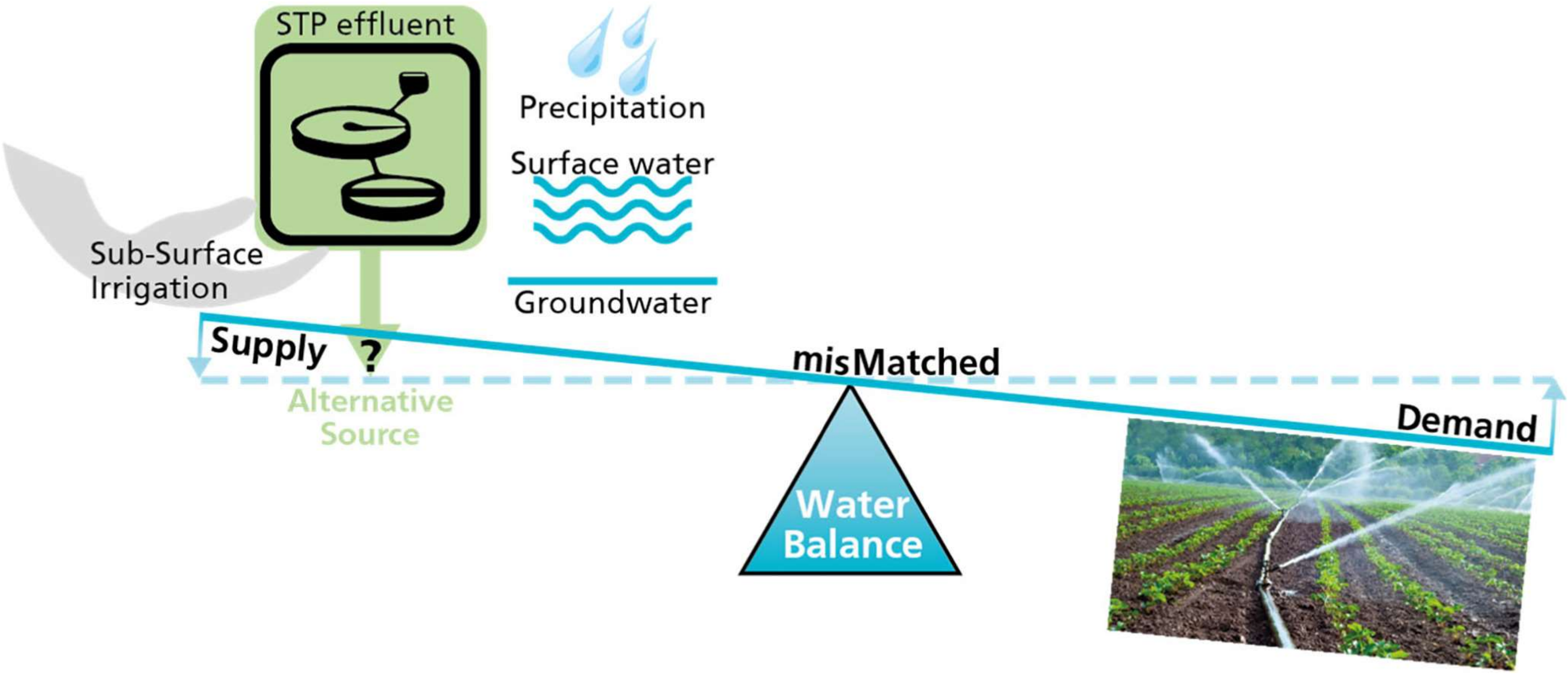
Fischer et al 2019

Treatment



Sjerps et al 2021

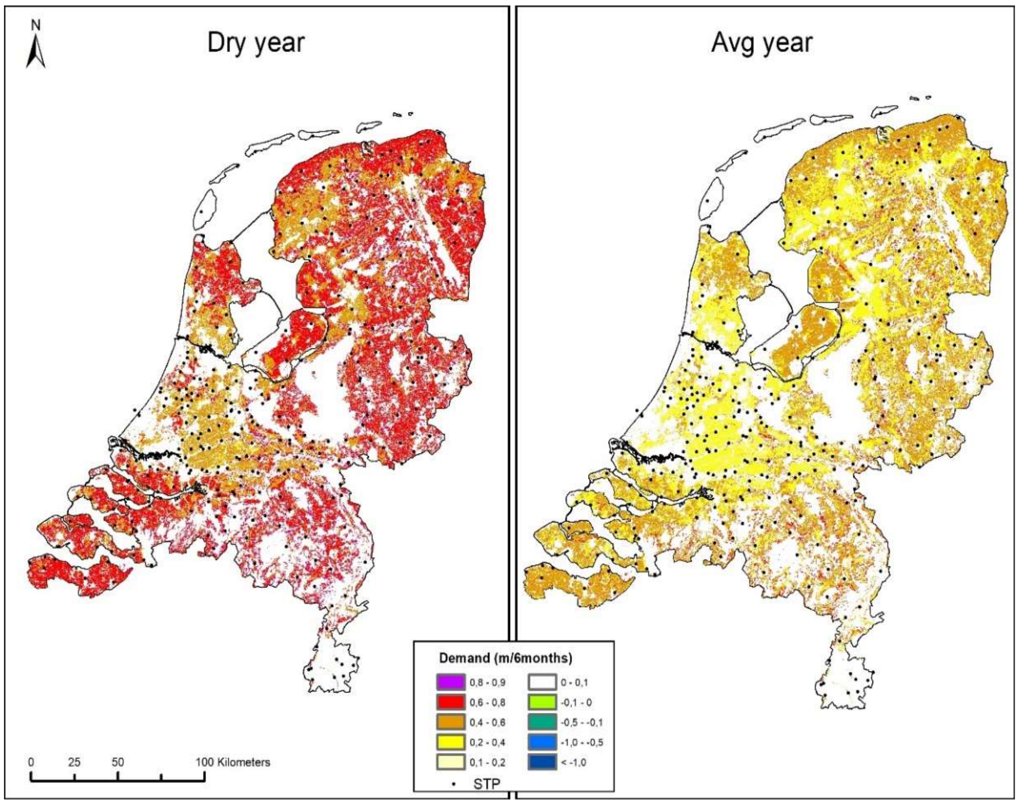
Shifting the imbalance?

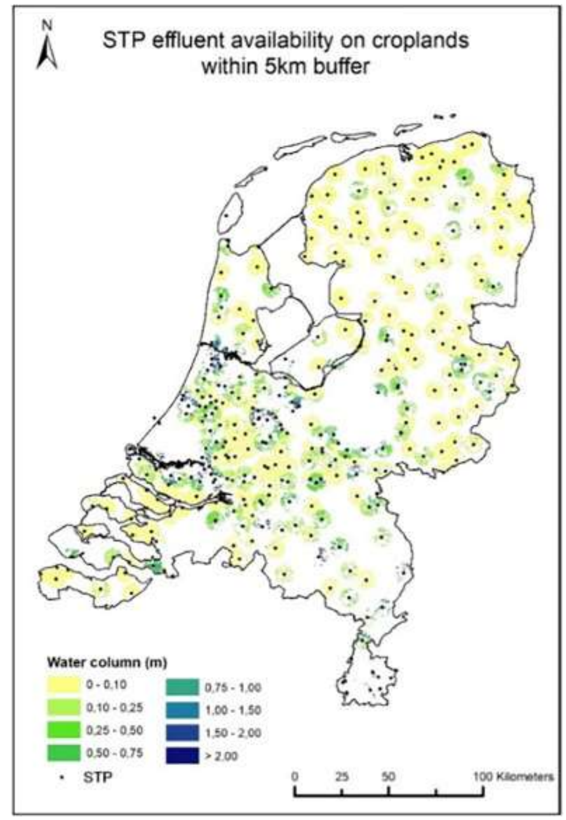


Narain-Ford et al 2021

University of Amsterdam
Faculty of Science

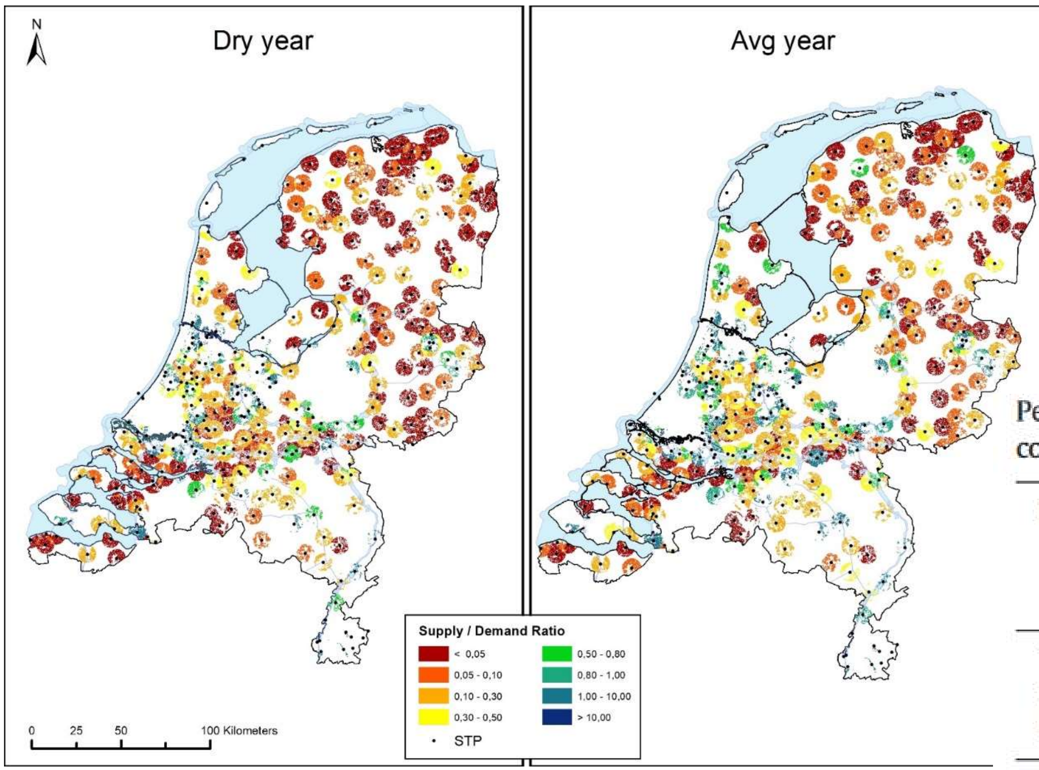
Water demand vs available effluent





Narain-Ford et al 2021

Demand satisfied



Percentage of croplands SSI water demand satisfied within three buffer distances and corresponding STP effluent reused.

Buffer [km]	Fulfilled water demand within buffer		Remaining STP effluent after SSI[a]	
	Average	Dry	Average	Dry
1	100%	100%	84%	76%
2	100%	81%	32%	17%
5	25%	17%	22%	16%

[a] 100% is the 6 months total of Dutch STP effluent of 0.95 billion m^3/y.

UNIVERSITY OF AMSTERDAM
Faculty of Science

<u>Neccesity</u> for **water-transition**

From discharge to retain

'Zorgen over aanhoudende droogte'

Snakken naar regen: 'Grootste droogte in ruim 40 jaar'

Alle waterbeheerders in Nederland snakken naar flinke regenbuien in juni, want het is veel en veel te droog. Beken en sloten vallen droog, het grondwater zakt ver weg en de waterkwaliteit neemt af. En de zomer moet nog beginnen.

Maarten van Ast

Wéér is het te droog. Wat gaan we eraan doen?

Waterbeheer De extreme droogte van 2018 heeft Nederland wakker geschud. Ook nu is het extreem droog. Onze omgang met water moet op de schop.

Marcel aan de Brugh 15 mei 2020 Leestijd 6 minuten

NIEUWS NEERSLAGTEKORT

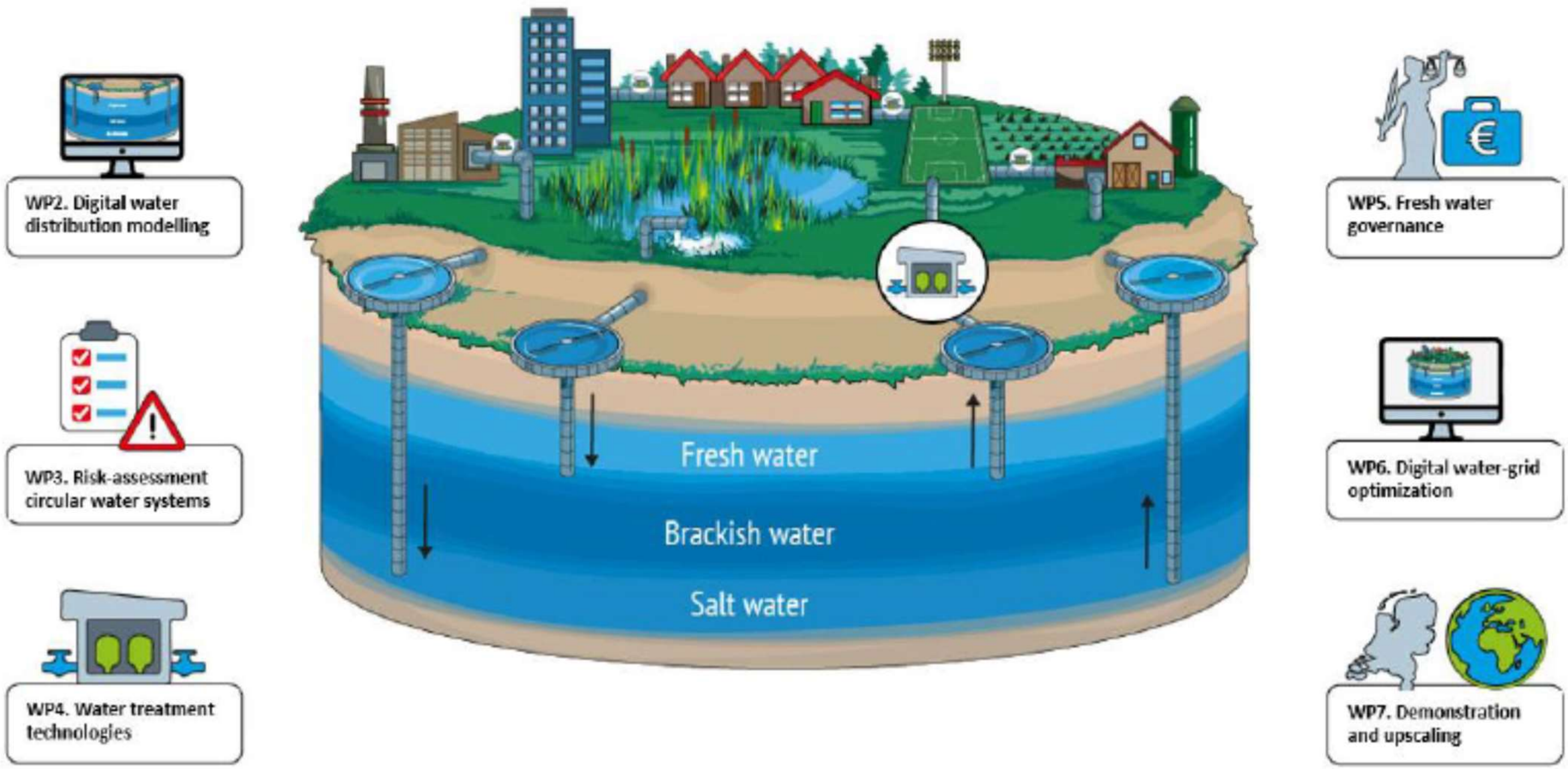
Wetenschappers slaan alarm: 'Droogte is een sluipmoordenaar'

Klagen over het weer is typisch Nederlands, maar nu is er reden: het is te droog, voor het derde jaar opeen. Met het actuele neerslagtekort van 40 millimeter doemt het spookbeeld op van 1976, het droogste jaar uit afgelopen decennia. Wetenschappers buigen zich over de vraag wat te doen.

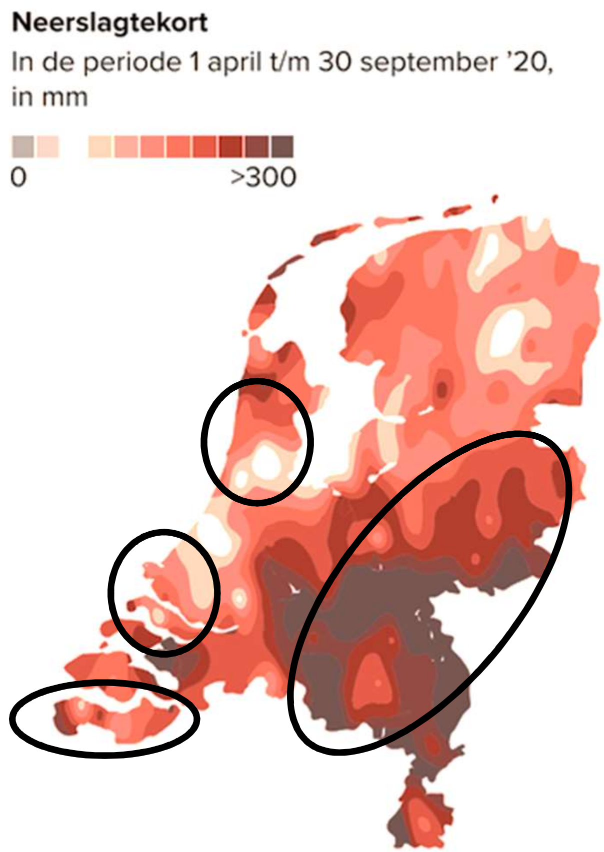
Jean-Pierre Geelen 16 april 2020, 20:00

UNIVERSITY OF AMSTERDAM
Faculty of Science

AquaConnect Key technologies for safeguarding regional water provision in fresh water stressed deltas



AquaConnect: Demonstration sites for alternative sources and implementation smart water-grid concept



University of Amsterdam
Faculty of Science

Essential elements for a Chemicals strategy for sustainability

Legislation, chemical design & essentiality, technology

Thanks to
Funders (NWO, EU)
Co-authors
YOU for listening

University of Amsterdam
Faculty of Science

Acknowledgements

NWO
Netherlands Organisation for Scientific Research

IBED
Institute for Biodiversity and Ecosystem Dynamics

KWR
Watercycle Research Institute

Wageningen
University & Research

KnowH2O
Consultancy, Innovation and Connection in Water

Copernicus