Water quality in water footprinting

Natalia Finogenova

GRoW cross-cutting topic “Water Footprint”

27 September 2018, Berlin

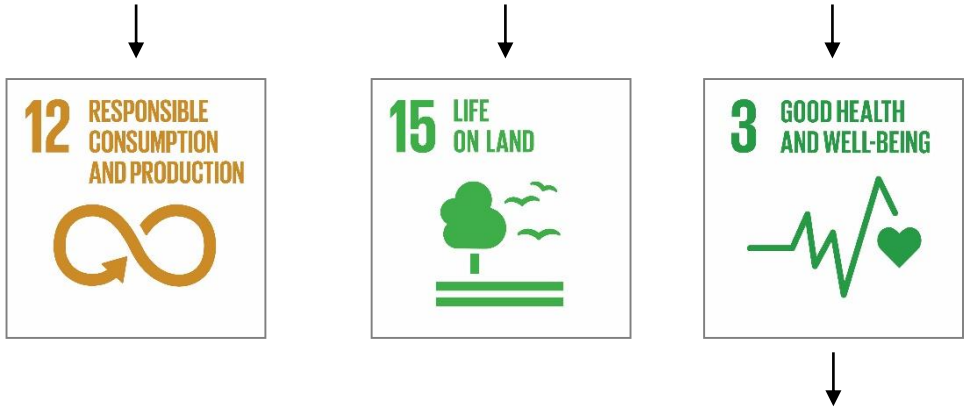
Technische Universität Berlin
Institute of Environmental Technology
Chair of Sustainable Engineering

The goal…

- UN SDG 6 „Clean Water and sanitation“ includes the taget 6.3:

“By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally“

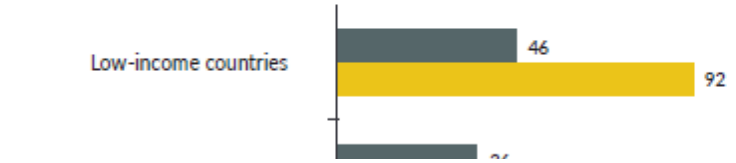
(UN, 2018)



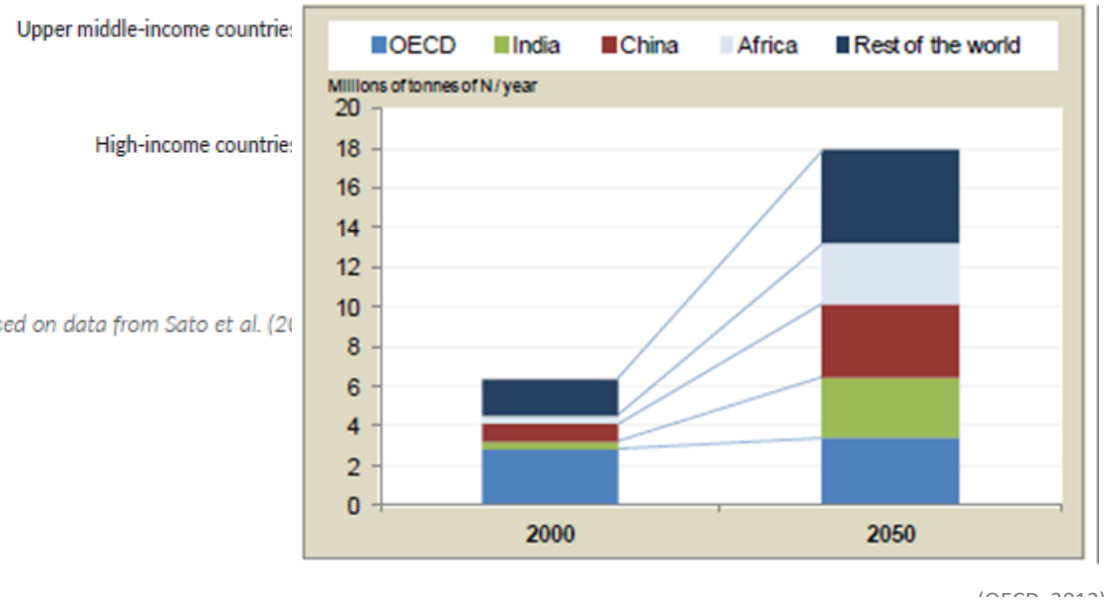
Indicator 3.9.2: Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene…

The challenge…

Figure 6 Percentage of untreated wastewater in 2015 in countries with different income levels, and aspirations for 2030 (50% reduction over 2015 baseline)



Nitrogen effluents from wastewater: Baseline, 2000 and 2050



Source: Based on data from Sato et al. (2

In Pakistan, about 20-40% of all registered diseases are caused by the use of unsafe water (Azizullah *et al.*, 2011).

What does ISO 14046 say?

- Environmental management – Water footprint – Principles, requirements and guidelines (ISO 14046:2014)

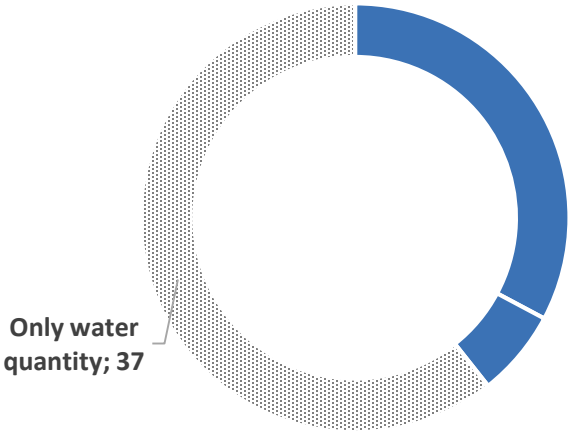
- **Principle**: *"A water footprint considers all environmentally relevant attributes or aspects of natural environment, human health and resources related to water (including water availability and water degradation)"*

- **Inventory:** *"The following shall be included…: Emissions to air, water and soil that impact water quality"*

- **Impact Assessment:** *Water footprint impact assessment method(s) shall consider the potential environmental impacts due to change in water quality and/or change in water quality…If water availability footprint only considers water quantity, it should be called water scarcity footprint…"*

How often is water quality considered in WF studies?

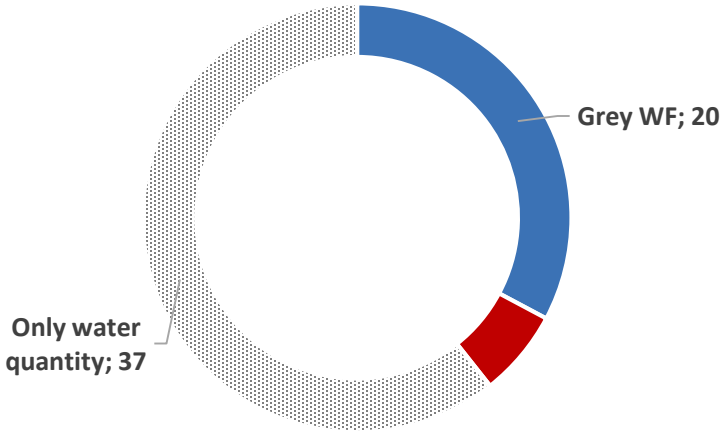
- Out of 61 WF studies, only 24 consider water quality



How often is water quality considered in WF studies?

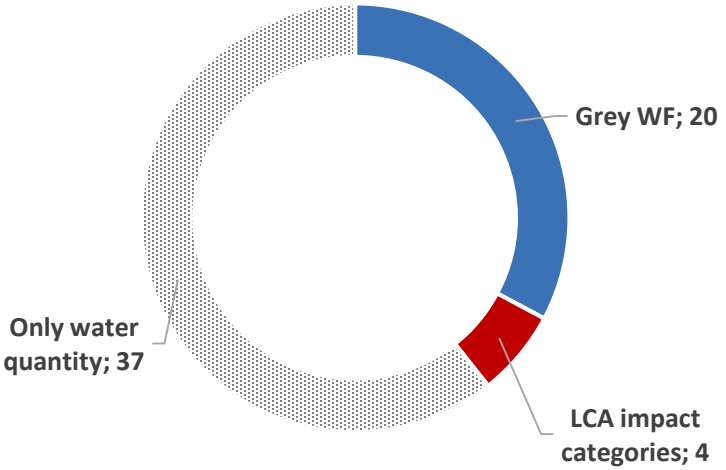
- Out of 61 WF studies, only **24 consider water quality**

- 20 studies calculate Grey WF



How often is water quality considered in WF studies?

- Out of 61 WF studies, only **24 consider water quality**
- 20 studies calculate Grey WF
- Only 4 studies perform a comprehensive impact assessment for the impact categories:
  - Eutrophication
  - Acidification
  - Eco-toxicity and
  - Human toxicity

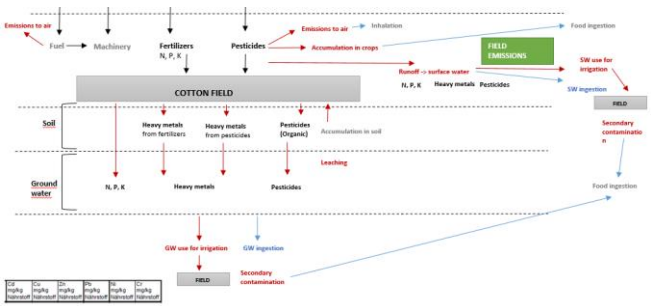


Water quality aspects in WF

How to consider water quality?

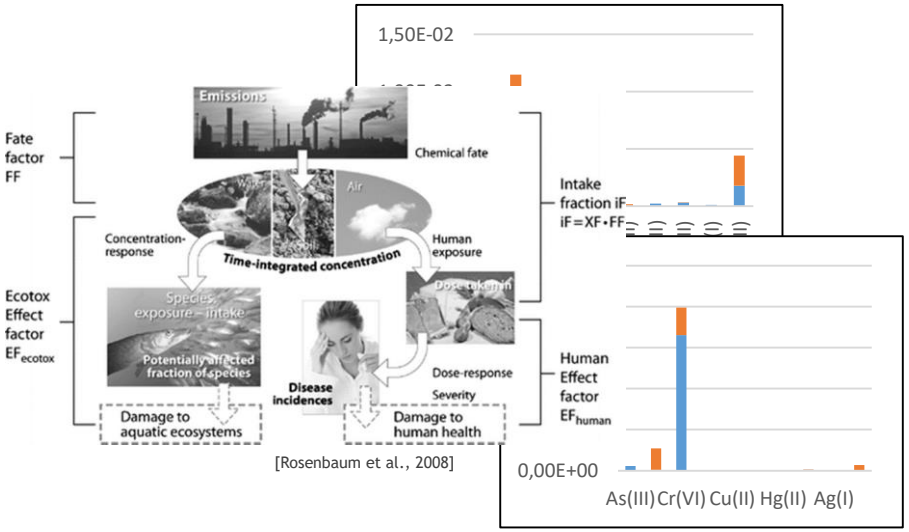
Inventory

- Which pollutants?
- Which models/assumptions should be used?



Impact assessment

- Which methods exists?
- Which methods are adequate for which goals?

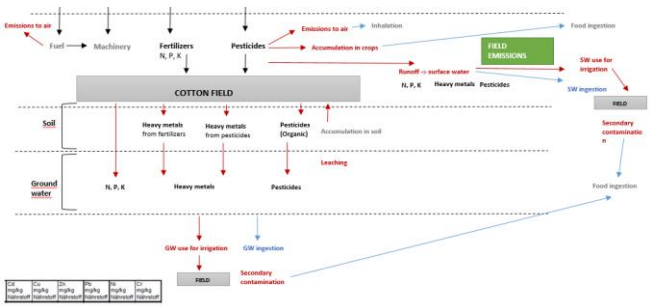


[Rosenbaum et al., 2008]

How to consider water quality?

Inventory

- Which pollutants?
- Which models/assumptions should be used?



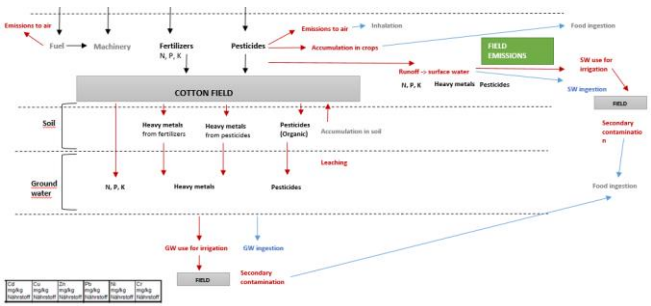
Agriculture:

- usually **N (nitrates)** (and sometimes P) is used as an indicator for water pollution;
- **pesticides' emissions** are usually not considered, although they may have high toxicity impacts on human health
- For nitrate emissions, an average of **30%** is assumed to leach into the groundwater, **for pesticides 1%.** Nevertheless, these values can significantly vary between different regions (due to soil types, climate etc.)
- There are some models for a detailed inventory analysis, e.g. SALCA and PestLCI

How to consider water quality?

Inventory

- Which pollutants?
- Which models/assumptions should be used?



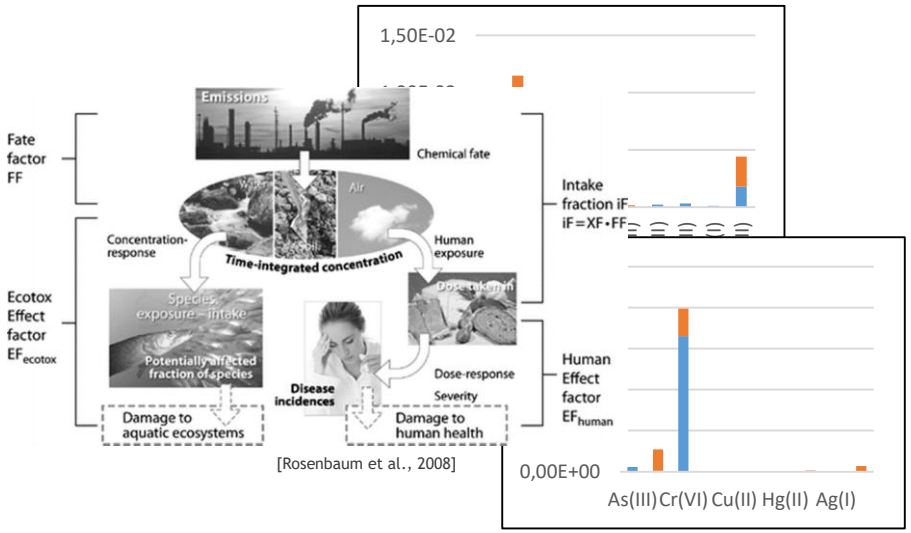
Industry:

- Different pollutants are relevant depending on the industrial sector
- **COD** (textiles), **heavy metals** (primary metal production - nickel, copper, gold), **TSS** (platinum processing) were considered in existing WF studies
- It is difficult to compile an inventory for many pollutants, because this data is often not available/test are expensive

How to consider water quality?

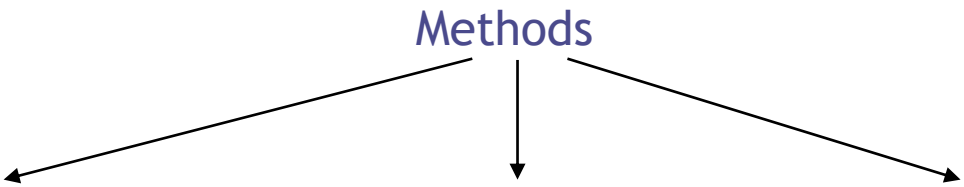
Impact assessment

- **Which methods exists?**
- Which methods are adequate for which goals?



[Rosenbaum et al., 2008]

Existing methods to address water pollution in WF



Distance-to-Target (DtT)

- **Grey WF (Hoekstra et al., 2011)**
- Water impact index (Bayart et al., 2014)
- Single weighted indicator (Ridoutt and Pfister, 2013)

Functionality

- **Boulay et al. (2011)**

Life Cycle Assessment (LCA)

- **ISO 14040, 14044 (ISO, 2006a, 2006b)**

Grey Water Footprint

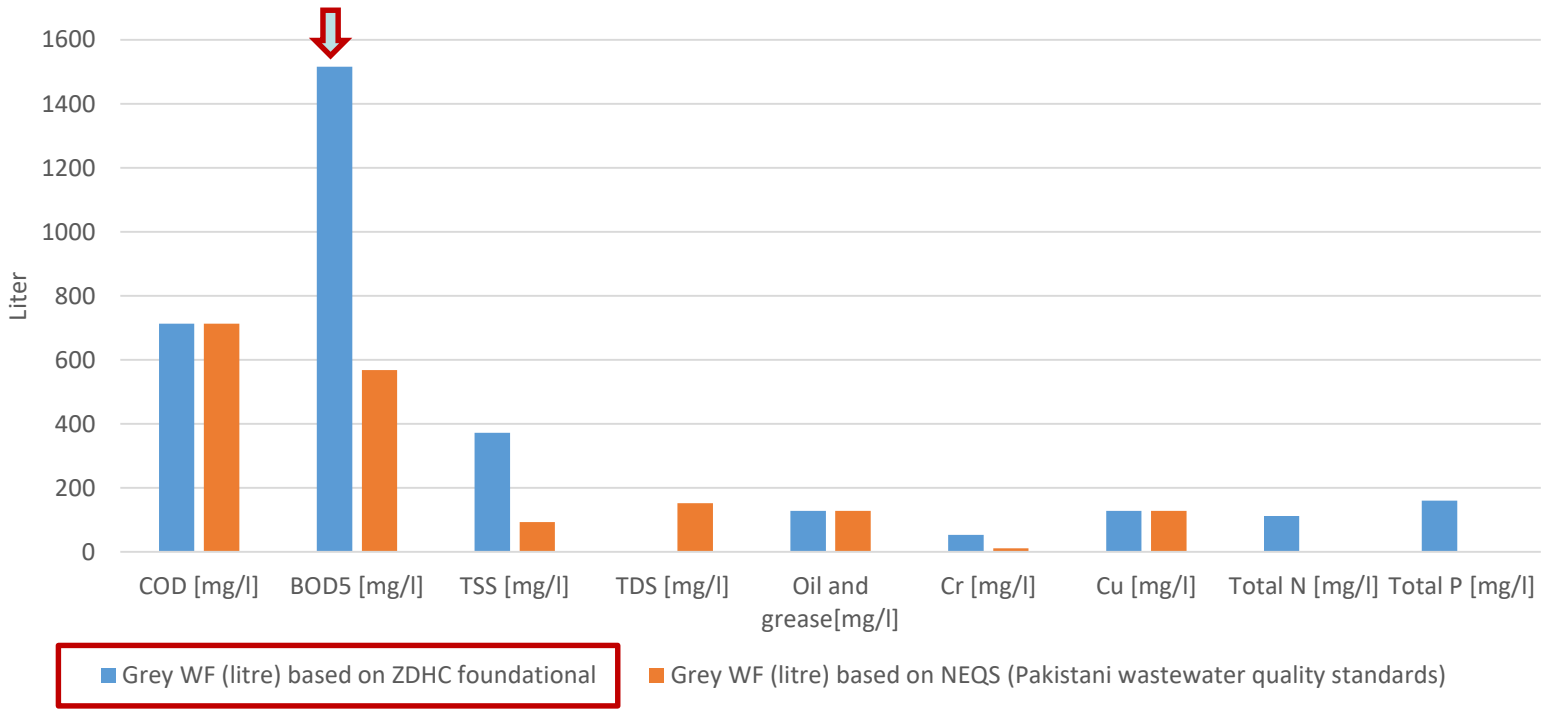
- The Grey WF stands for "*the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards*" (Hoekstra et el., 2011).

$$Grey\ WF = \frac{L}{c_{max} - c_{nat}}$$

L - load of the pollutants (mg)

C_{max} - concentration threshold (mg/l)

C_{nat} - natural concentration (mg/l)



Grey Water Footprint

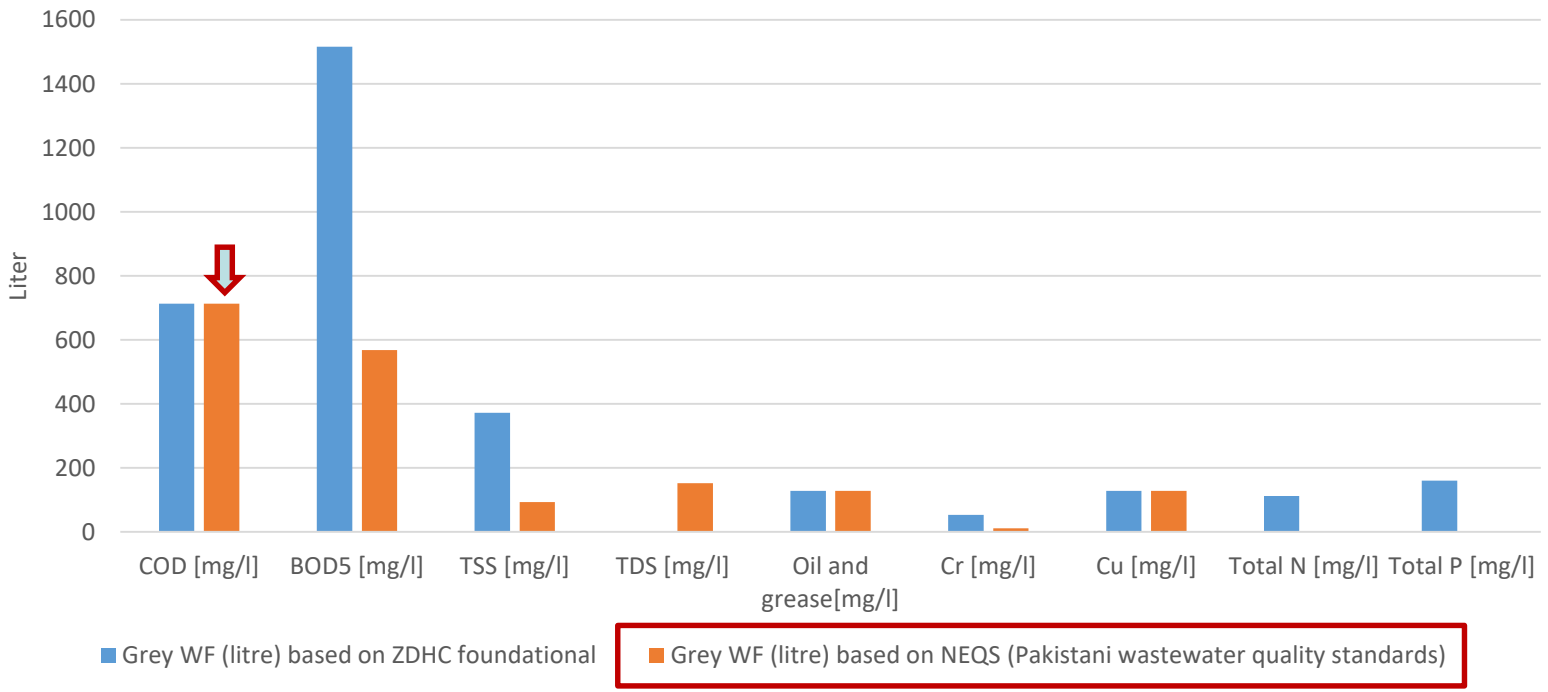
- The Grey WF stands for "*the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards*" (Hoekstra et el., 2011).

$$Grey\ WF = \frac{L}{c_{max} - c_{nat}}$$

L - load of the pollutants (mg)

C_{max} - concentration threshold (mg/l)

C_{nat} - natural concentration (mg/l)



Grey Water Footprint

- The Grey WF stands for "*the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards*" (Hoekstra et el., 2011).

Pros

+ easy to apply

+ understandable and well-known

+ default values for leaching rates and surface runoff with some regional (climate, soil) specifications are available

Cons

- is usually based only on one pollutant

- implies (justifies?) that there is enough water for dilution

- depends on the thresholds used (e.g. national, WHO)

- do not provide any information on impact on human health and ecosystems

Water functionality

- Eleven water users were identified, each of them has specific requirements on water quality. Based on these requirements, eight water functionality classes were established.
- It is assumed, that a user can use water only of the required class or better. Thus, water pollution (discharging water of a lower class than a user needs) leads to water scarcity for this specific user.

	1	2a	2b	2c	2d	3	4	5
	Excellent low coliforms, low toxic	Good low coliform, medium toxic	Average Medium coliform, medium toxic	Average Tox Low coliform, higher toxic	Average Bio High coliforms, low toxic	Poor High coliform, medium toxic	Very Poor High Coliform, high toxic	Unusable Other - Unusable
Domestic 1	√	x	x	x	x	x	x	x
Domestic 2	√	√	√	x	x	x	x	x
Domestic 3	√	√	√	√	√	√	√	x
Agriculture 1	√	√	x	√	x	x	x	x
Agriculture 2	√	√	√	√	√	√	x	x
Fisheries	√	x	x	x	√	x	x	x
Industry	√	√	√	x	x	x	x	x
Cooling	√	√	√	√	√	√	√	x
Recreation	√	√	x	√	x	x	x	x
Transport	√	√	√	√	√	√	√	√
Hydropower	√	√	√	√	√	√	√	√

Boulay et al. (2011)

Water functionality

- Eleven water users were identified, each of them has specific requirements on water quality. Based on these requirements, eight water functionality classes were established.
- It is assumed, that a user can use water only of the required class or better. Thus, water pollution (discharging water of a lower class than a user needs) leads to water scarcity for this specific user.

Pros	Cons
+ a comprehensive assessment of all relevant water quality parameters	- a lot of data is needed (overall 146 parameters for water in- and output!)
+ specific needs of different users are addressed	- It is implied that a user does not use water if it is polluted. Nevertheless, people 1) might be not aware of water pollution (e.g. pesticides), 2) rather use polluted water than suffer from water scarcity

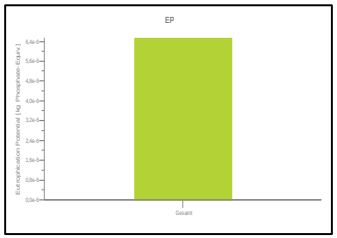
- Modelling impacts using the life cycle impact assessment (LCIA) methods by multiplying inventory (emissions) with the characterization factors (CFs) for each pollutant. The impact categories eutrophication, eco-toxicity and human toxicity are usually quantified.

Inventory data:

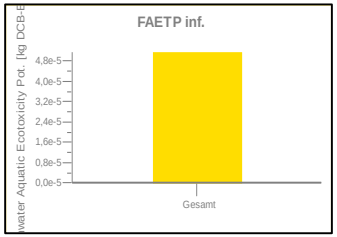
- COD
- BOD
- TSS
- TDS
- pH
- Total-N
- Total-P
- Cr
- Cu
- As
- Ni

Impact assessment:

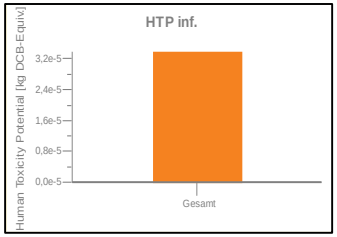
Eutrophication



Eco-toxicity



Human toxicity



Impact assessment (endpoint / areas of protection):

Ecosystem damage

Human health

Life Cycle Assessment

- Modelling impacts using the life cycle impact assessment (LCIA) methods by multiplying inventory (emissions) with the characterization factors (CFs) for each pollutant. The impact categories eutrophication, eco-toxicity and human toxicity are usually quantified.

Pros

+ a comprehensive assessment of (almost) all relevant water quality parameters

+ provides information on impacts on human health and ecosystems

+ models detailed cause-effect chains (fate of the contaminants in the environment, exposure of population to the pollutants)

Cons

- a lot of data is needed for compiling inventory

- some models do not reflect region-specific cause-effect chains, thus, the results might be not representative for a region

Questions for the workshop

- How do you address water quality in water footprinting in your project?
  - Which pollutants do you consider?
  - Do you make any assumptions for the inventory (e.g. leaching rates)?

- Do you calculate Grey WF or perform an impact assessment (impacts on human health and ecosystems)?

- How do you use these results (e.g. supporting instruments for desicion-making)?

Thank you a lot for your attention!

Technische Universität Berlin
Institute of Environmental Technology
Chair of Sustainable Engineering

References

- Azizullah, A. *et al.* (2011) 'Water pollution in Pakistan and its impact on public health — A review', *Environment International*. Pergamon, 37(2), pp. 479–497. doi: 10.1016/J.ENVINT.2010.10.007
- Bayart, J. B. *et al.* (2014) 'The Water Impact Index: A simplified single-indicator approach for water footprinting', *International Journal of Life Cycle Assessment*, 19(6), pp. 1336–1344. doi: 10.1007/s11367-014-0732-3
- Boulay, A. M. *et al.* (2011) 'Categorizing water for LCA inventory', *International Journal of Life Cycle Assessment*, 16(7), pp. 639–651. doi: 10.1007/s11367-011-0300-z
- Hoekstra, A. Y., Chapagain, A. K. and Aldaya, M. M. (2011) *The Water Footprint Assessment Manual*
- ISO (2006a) *Environmental management — Life cycle assessment — Principles and framework. International Organization for Standardization, Ed.* Geneva, Switzerland
- ISO (2006b) *Environmental management — Life cycle assessment — Requirements and guidelines. International Organization for Standardization, Ed.* Geneva, Switzerland
- OECD (2012) *Water, OECD Environmental outlook to 2050: The Consequences of inaction*. doi: 10.1787/9789264122246
- Ridoutt, B. G. and Pfister, S. (2013) 'A new water footprint calculation method integrating consumptive and degradative water use into a single stand-alone weighted indicator', *International Journal of Life Cycle Assessment*, 18(1), pp. 204–207. doi: 10.1007/s11367-012-0458-z
- UN Water (2017) 'The United Nations World Water Development Report 2017. Facts and figures'
- United Nations (2018) *Sustainable Development Goals*. Available at: https://sustainabledevelopment.un.org/sdgs