Water quality in water footprinting

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GRoW cross-cutting topic “Water Footprint”

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The goal...

- UN SDG 6 „Clean Water and sanitation“ includes the target 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“

Indicator 3.9.2: Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene...
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
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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 exist?
- Which methods are adequate for which goals?

[Rosenbaum et al., 2008]
Inventory

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
Impact assessment

How to consider water quality?

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

[Graphical representation of impact assessment]

[Rosenbaum et al., 2008]
Existing methods to address water pollution in WF

**Methods**

- **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 al., 2011).

\[
\text{Grey WF} = \frac{L}{C_{\text{max}} - C_{\text{nat}}}
\]

- \( L \) - load of the pollutants (mg)
- \( C_{\text{max}} \) - concentration threshold (mg/l)
- \( C_{\text{nat}} \) - natural concentration (mg/l)

![Graph showing Grey WF based on ZDHC foundational and NEQS standards](image-url)
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![Graph showing comparison between Grey WF based on ZDHC foundational and NEQS standards](image)

Grey WF (litre) based on ZDHC foundational
Grey WF (litre) based on NEQS (Pakistani wastewater quality standards)
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 al., 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.

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<th>2c Average (Low coliform, higher toxic)</th>
<th>2d Average (Bio High coliforms, low toxic)</th>
<th>3 Poor (High coliform, medium toxic)</th>
<th>4 Very Poor (High Coliform, high toxic)</th>
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**Pros**

+ a comprehensive assessment of all relevant water quality parameters
+ specific needs of different users are addressed

**Cons**

- a lot of data is needed (overall 146 parameters for water in- and output!)
- 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
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.

**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

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**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 decision-making)?
Thank you a lot for your attention!
References


