Modelització dels aspectes sanitaris i anàlisi del cicle de vida de la recàrrega de l’aqüífer del Port de la Selva

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El Port de la Selva

Topics for today

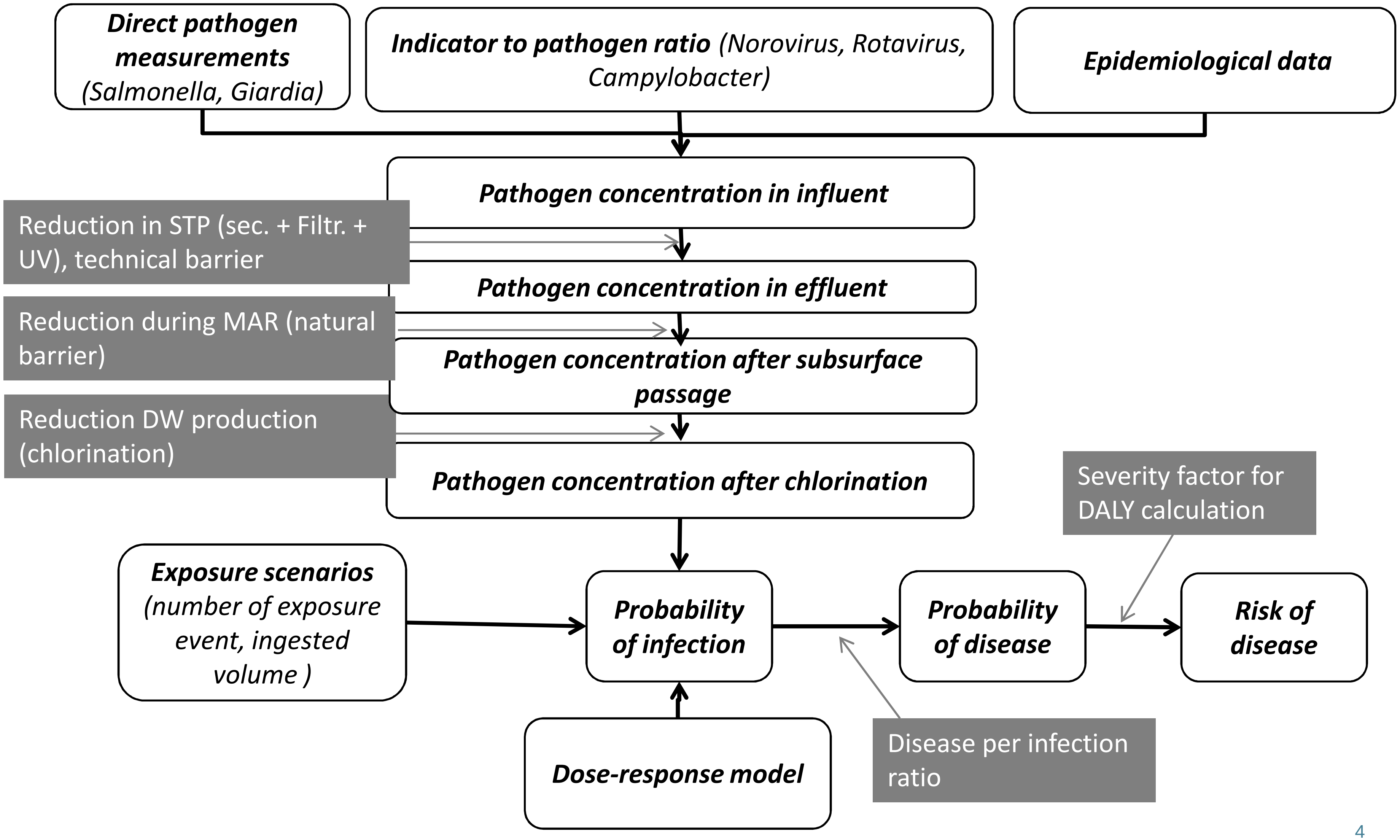
1. Microbial risk assessment
2. Presence of pharmaceutical residues
3. Life cycle assessment

Microbial risk assessment
(World health organization approach)

- Safe vs. unsafe? → No!
- They´re is more than black/white or yes/no.
- Our approach:
  - We work with a lot with worst case assumptions.
  - Use probabilities (How sure are you?)
  - How sure are we, that the inhabitants of El Port are not harmed by microbial contamination?

  - WHO definition of “not harmed”:
    - Additional microbial risk: < 1 µDALY
      (e.g. less than 1 virus/100.000 L present in water)

Microbial risk assessment
(World health organization approach)



Overview reus

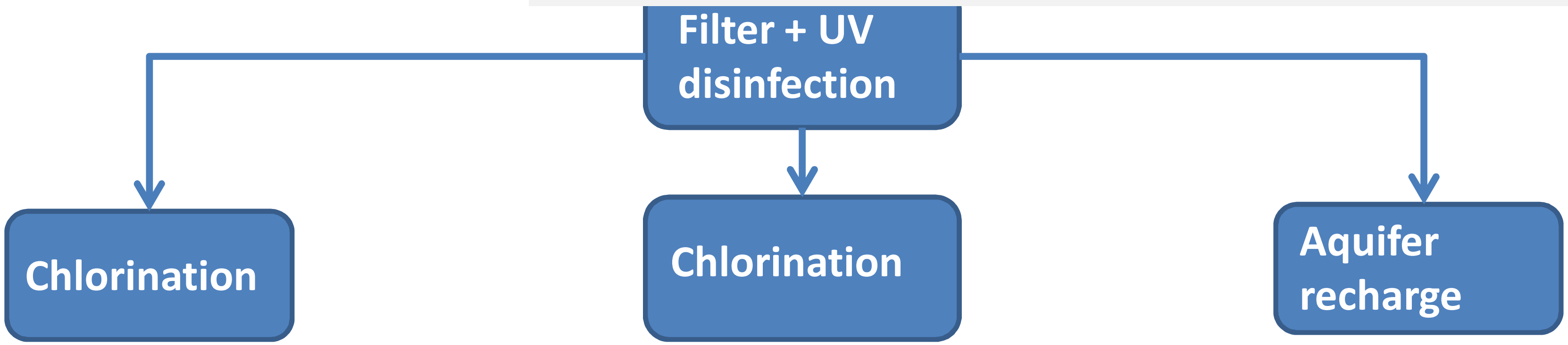
What is log-reduction?		1.000.000 /L
1log:	90 % removal	100.000 /L
2log	99 %	10.000 /L
3 log	99.9 %	1.000 /L
4 log	99.99 %	100 /L
5 log	99:999 %	10 /L
6 log	99.9999 %	1 /L
7 log	99.99999 %	0.1 /L
8 log	99.999999 %	0.01 /L
9 log	99.9999999 %	0.001 /L
10 log	99.99999999 %	0.0001 /L

<u>Assumptions for raw sewage:</u>

Campylobacter: 1.000.000/L

Rotavirus 31.000/L

Cryptosporidium 10.000/L

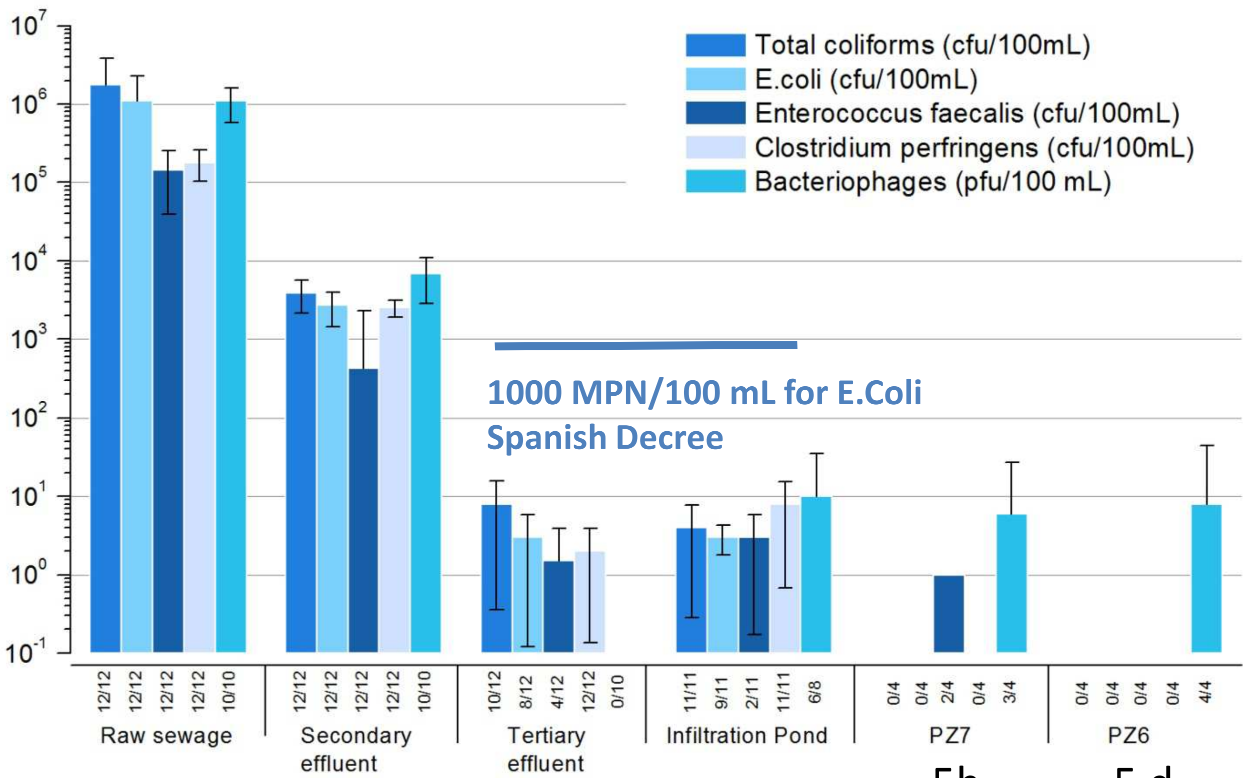


	Urban irrigation	Private irrigation	Indirect potable reuse

<u>Required reduction compared to raw sewage to reach 1 µDALY (log reduction):</u>

	Urban irrigation	Private irrigation	Indirect potable reuse
Campylobacter:	**6.12**	**5.4 - 6.37**	**9.98**
Rotavirus	**5.6**	**5.8**	**9.45**
Cryptosporidium	**3.34**	**3.6**	**7.2**

Microbiology data from El Port reuse site



5h 5 d

Travel time:

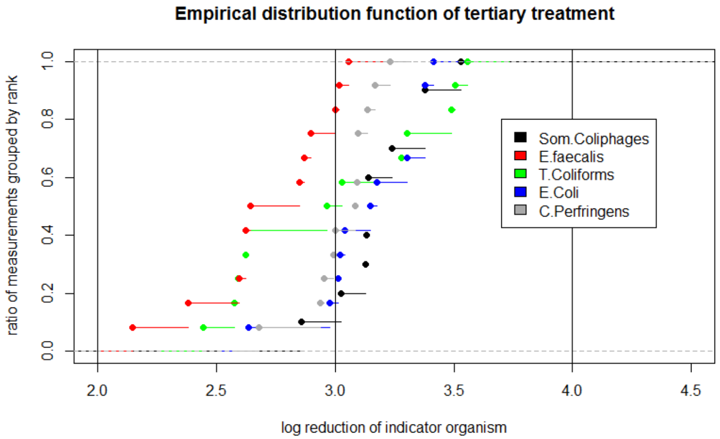
- Royal degree for reuse fulfilled (infiltration)
- Good removal of bacteria during subsurface passage
- Little removal of bacteriophages in groundwater after short residence time (in line with literature → need longer time)

→ 500 d travel time: Not measureable any more → need for calculation

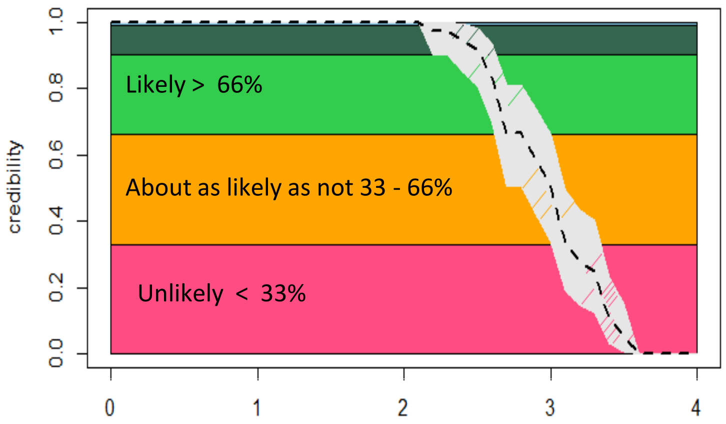
TT = mean travel time of infiltrate from pond to observation well
4/6 = four positive out of six samples

Example of performance assessment (Filter + UV disinfection)

Sampling campaigns in spring 2016



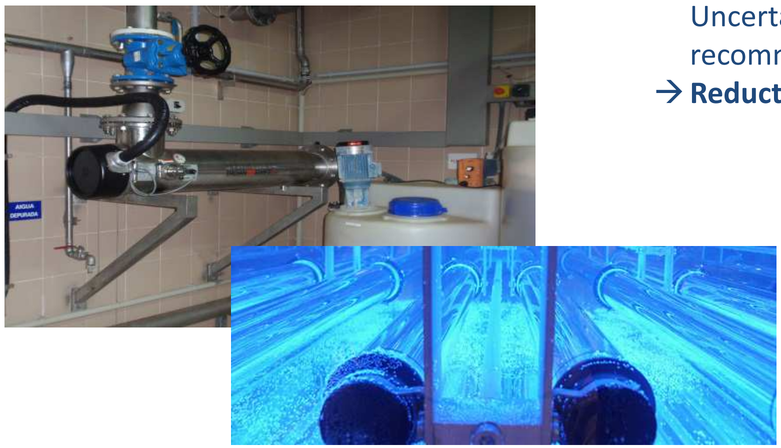
Performance and uncertainty assessment (example for bacteria reduction)



→ **Virtually certain that log reduction for bacteria is > 2 log units for bacteria**

→ **High confidence (79 - 98%) that reduction of bacteria by UV disinfection at least 2.6 log**
Uncertainty result of number of samples (n = 36). Reduction by taking more samples recommended.

→ **Reduction of parasites and viruses by 2.7 log and 3 log respectively**



Physical disinfection

Required additional reduction after UV disinfection

Reference pathogens for bacteria, viruses and parasites	Indirect potable reuse	Urban irrigation	Private irrigation
Campylobacter	**4.88**	**1.9**	**0.3 - 1.27**
Rotavirus	**3.65**	**0.6**	**0.8**
Cryptosporidium	**3.3**	**- 0.7**	**- 0.4**

Reduction during subsurface passage (indirect potable reuse)

Parameter	Distribution	Log Reduction	Source
Traveltime	Range	N (μ = 500, sd = 100)	*Model Amphos 21*
Reduction during infiltration Campylobacter	*Range*	*2 – 6* ***Used value 2***	*WHO Guidelines for Drinking Water Quality*
Reduction during subsurface passage Campylobacter	*T90* *3d -7d*	*> 20* ***Used value 20***	Sidhu et al. 2015, from diffusion chamber experimentes of 4 different MAR sites
Reduction during infiltration Cryptosporidium	*Range*	*0.5 - 5* ***Used value 0.5***	*WHO Guidelines for Drinking Water Quality*
Reduction during subsurface passage Cryptosporidium	*T90* 56-120d	4.2 - 8.9 ***Used value 4.2***	Sidhu et al. 2015 from diffusion chamber experimentes of 4 different MAR sites
Reduction during infiltration Rotavirus	*Range*	***0.25*** *- 4* ***Used value 0.25***	*WHO Guidelines for Drinking Water Quality*
Reduction during subsurface passage Rotavirus	*T_{90} = random* *(min = 30, max = 100)*	*>* ***5*** *log* ***Used value 5***	*Australian Guidelines for Water recycling*
Reduction chlorination (drinking water treatment)	*Point estimate*	*2 log viruses* *2 log bacteria* *0.5 log protozoa*	*WHO Guidelines for Drinking Water Quality*

Reference pathogens	Indirect potable reuse		
	WWTP, UV, MAR, Cl	**WWTP, MAR, UV (failure of Cl at DWTP)**	**WWTP, MAR, Cl (failure of Filter + UV)**
Campylobacter	**-19.12**	**-17.12**	**-16.52**
Rotavirus	**- 3.55**	**- 1.55**	**0.2**
Cryptosporidium	**- 2**	**- 1.5**	**0.5**

Conclusions Microbial Risk Assessment

- The required log reduction for bacteria, virus and parasites can be achieved for all three reuse options:
  - In line with WHO target of 1µDALY
  - Even with worst case assumptions (high initial concentration + low performance of treatment steps) → real risk will be most likely much lower
  - But: All treatment steps need to be in operation!

- Most critical treatment step is the filter + UV disinfection:
  - If UV disinfection fails, the reuse of water has to be stopped (for both irrigation and infiltration)
  - In 2013-2014 in some cases very low disinfection performance (UV lamps replaced in 2014) →room for improvement

Estimation on trace organic transfer from secondary effluent via MAR to drinking water well

Trace organics	Secondary Effluent (µg/L)	Estimate drinking water (µg/L)	Health orientated guideline value in Germany (µg/L) **	Prediction with activated carbon treatment (µg/L)
Carbamazepine	0.2	0.005 - 0.08 (Median 0.04)	0.3	< 0.01
Gabapentine*	1.6	0.17-0.63 (Median 0.36)	1.0	0.08-0.35 (Median < 0.2)
Sulfamethoxazole	0.84	±0.050	0.1	< 0.01
Diuron	2.3	0 – 0.002 (Median: 0.001)	0.1 Legal limit	< 0.0001
Terbutryne	0.15	0-0.0008 (Median: 0.0005)	0.1 (legal limit)	< 0.00005

*assumption: no degradation in MAR (worst case assumption) → degradable, but no degradation coefficient known yet

**Health orientated guideline value: considered to be safe for 70 a of consumption by German EPA

GAC with max. 5000 BV

Conclusion on trace organic contaminants

- Various trace organic contaminants present in WWTP effluent
- Without additional treatment step:
  - Transfer of pesticides unlikely
  - Transfer of pharmaceutical residues very likely, but still below health orientated guideline values from German EPA
- Planning for full-scale activated carbon filter ongoing (pilot test this summer, lab test for GAC selection performed by KWB)
- With additional treatment step (Prediction based on piloting in Berlin):
  - Additional safety barrier against pesticides
  - Transfer of pharmaceutical strongly reduced (Carbamezepine, Sulfamethozazol), most difficult compound to be removed is Gabapentine

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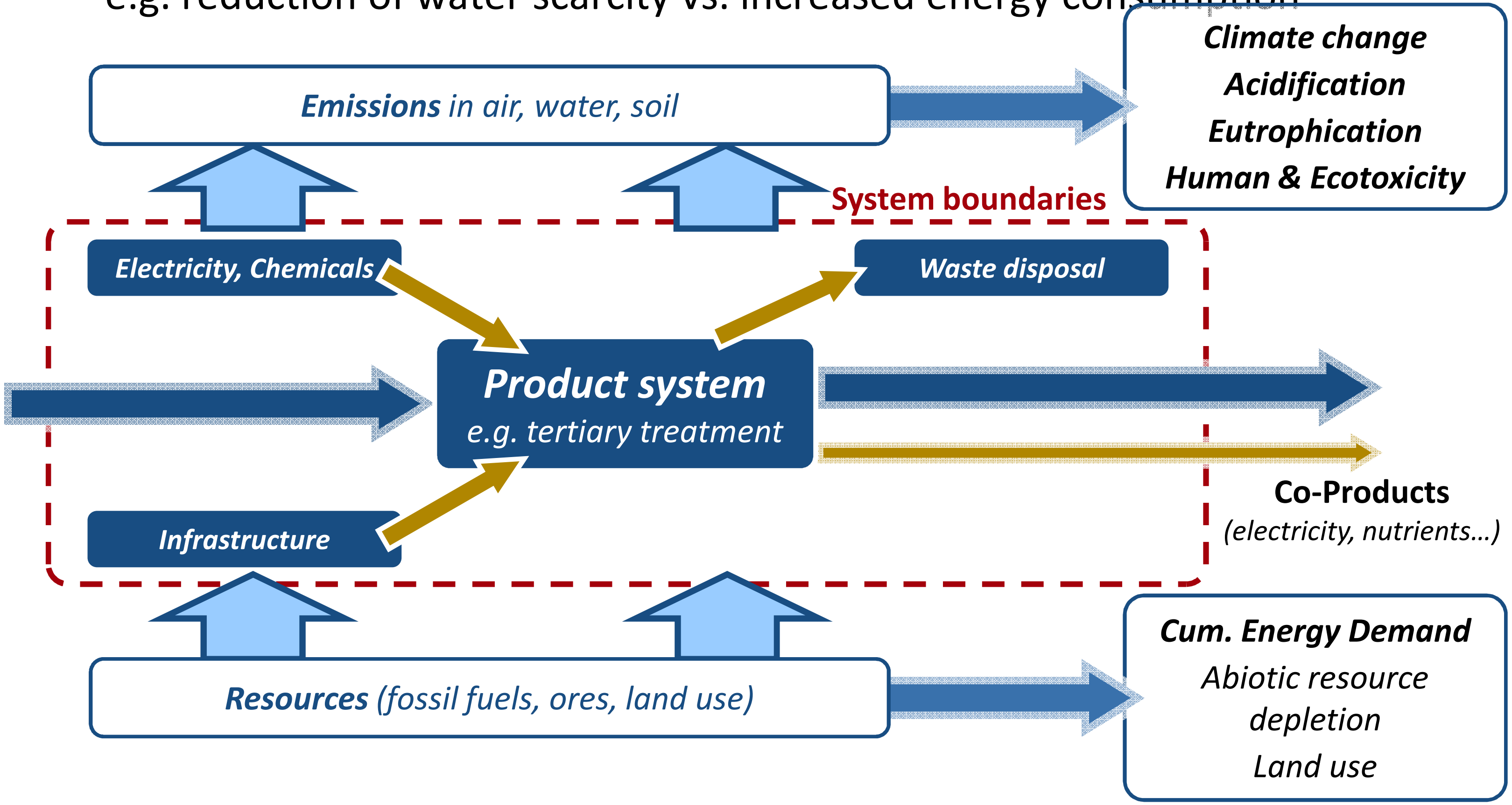
Comparison of treatment option
El Port de la Selva

Fabian Kraus, 05/2016

Methodology of LCA

- **LCA** is a standardized holistic tool to assess direct and indirect effects
- **LCA** considers chemical & electricity production, infrastructure…
- **Balancing** ecological benefits vs. ecological burdens

  e.g. reduction of water scarcity vs. increased energy consumption



Scope of LCA

Scope of LCA for El Port de la Selva:

„Analysis of the alternatives to increase the availability of water resources in El Port de la Selva by 100 Mio liters/year"

Scenarios for LCA Case Study

0. status until 2015

- WWTP effluent discharge to sea, drinking water from groundwater

1. reuse A with filter, GAC, UV (and Cl) in tertiary treatment

- partial WWTP effluent irrigation to private gardens (summer)
- partial WWTP effluent infiltration into aquifer (winter)

2. reuse B with UF, RO (and Cl) in tertiary treatment

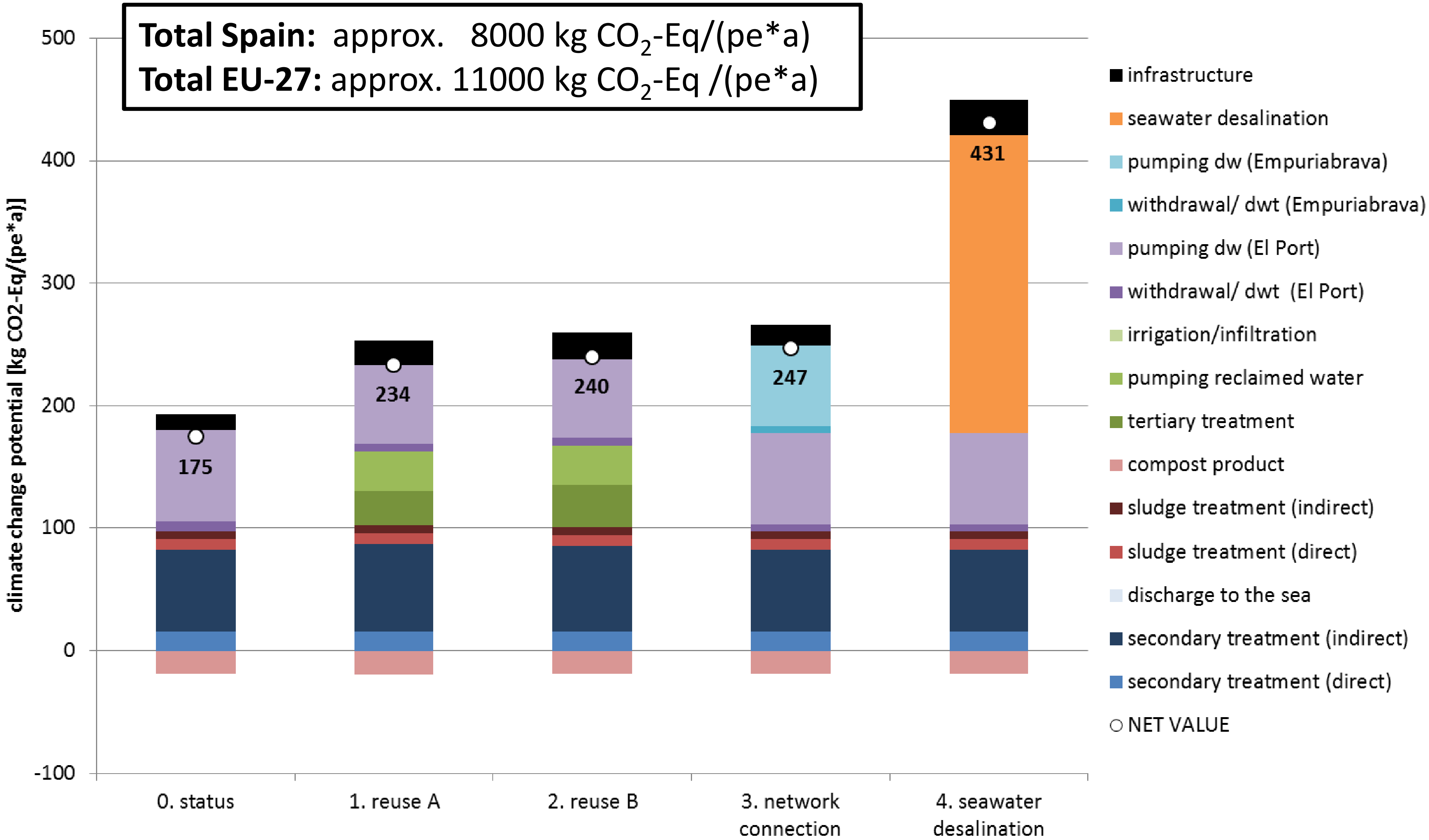
- partial WWTP effluent irrigation to gardens (summer)
- partial WWTP effluent infiltration into aquifer (winter)

3. network connection

- Pumping water from Empuriabrava

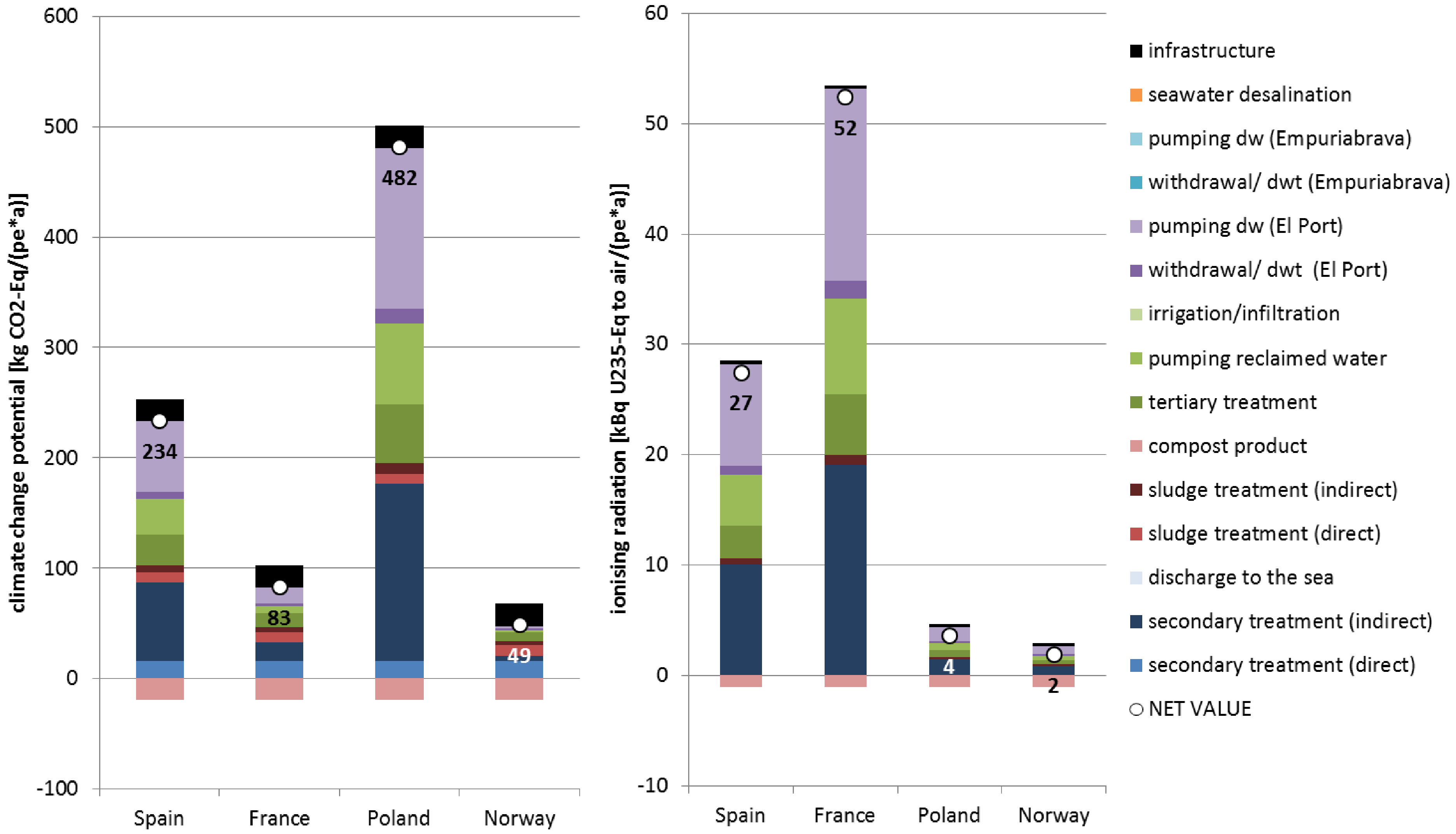
4. seawater desalination

global warming potential



Data-Set and total value from 2008

global warming potential and ionising-radiation of **Reuse A** for different **electricity mixes** of…



Data-Set and total value from 2008

Conclusion life cycle assessment

- All measures to increase water availability are associated with additional energy consumption and green house gas emissions (only other solution: reduce water consumption)
- Ranking of GHG emissions:
  - Seawater desalination >> wastewater desalination/pipeline from Empuriabrava/ infiltration
  - High exchange rate of activated carbon makes wastewater desalination an potential alternative to current scheme
- A high share of renewable energy in the national energy mix reduces the GHG emissions
- Options to reduce GHG emissions:
  - Direct pipeline from WWTP to infiltration pond
  - Replacement of pressurized filtration by gravity sand filter (reduction of energy demand)

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