Addressing the Impact of the Mixture Allocation Factor (MAF) on Environmental Risk Assessment: Refining Regulatory Exposure Predictions Using Spatial Data and Modelling Approaches

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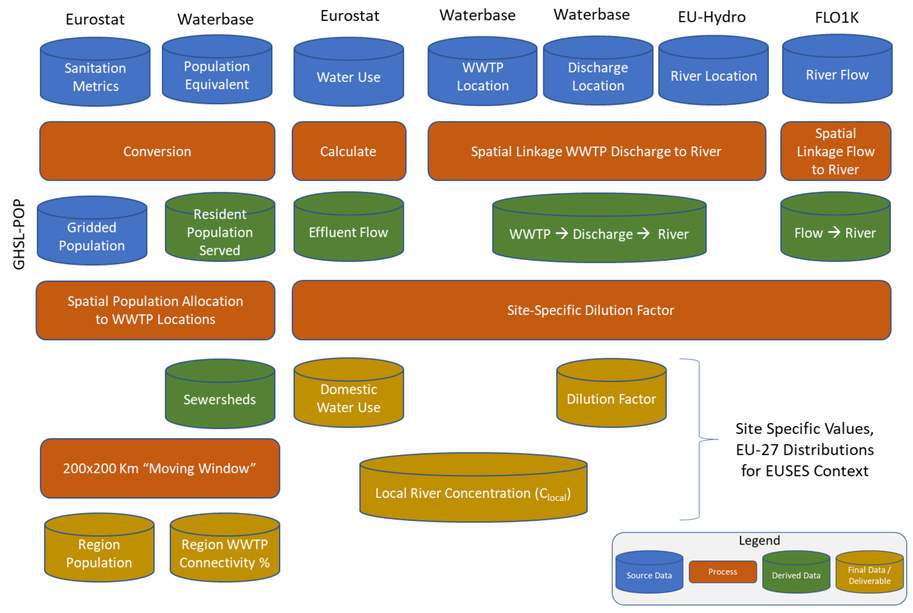
Introduction

- The European Commission has proposed a **mixture allocation factor (MAF)** to address uncertainties associated with chemical mixtures in the environment.
- The MAF introduction may require industry to refine current risk assessments (which tend to be highly conservative) by reevaluating hazard values and/or **exposure scenarios.**
- The current regulatory model is the European Union System for the Evaluation of Substances (**EUSES**) was developed over 25 years ago when the EU included only 15 countries.
- In this work, we explored updating some EUSES modelling defaults to better reflect spatial datasets available for the EU-27 (the current European Union countries).
- Environment and Health – Risk Assessment & Management (**ERASM**), a joint research platform of the European Detergents and Surfactants Industries, explored 'real world' data and developed a spatially explicit model (the **ERASM *Spatialized C_{local} Model***) that is both **probabilistic and more representative** than current EUSES default parameters and placed these refined data **in context** with default EUSES values.
- A **case study** was performed for linear alkylbenzene sulphonate (LAS) comparing predicted environmental concentrations (PECs) for freshwater using EUSES including both the current default data and the geospatial model utilizing 'real world' data. Case study results were **compared to publicly available monitoring data** in France and Germany.

Datasets & ERASM *Spatialized C_{local} Model*

- We developed a spatially explicit model to estimate PECs at freshwater discharge locations of almost 20,000 Urban Wastewater Treatment Plants (UWWTPs) in the current 27 European Union countries
- UWWTPs from Waterbase (EEA, 2020a) provided population equivalents (converted to resident population) and UWWTP discharge locations
- Country-level household water use data were sourced primarily from Eurostat (Eurostat, 2023a)
- Hydrologic network from EU-Hydro (EEA, 2020b) was spatially linked to UWWTP discharge locations (Fig. 1)
- River flow (FLO1K)(Barbarossa, 2018) were spatially linked to each UWWTP discharge river segment (Fig. 2)
  - 55 years of annual mean & monthly low flows; decadal means; 30-year long term average (1986-2015)
- Local dilution factors calculated for each UWWTP discharge location
- Spatial allocation delineated local "sewersheds" with UWWTP location and gridded population data (Fig. 3)
- Region UWWTP connectivity and population calculated using a "moving window" approach (Fig. 4)



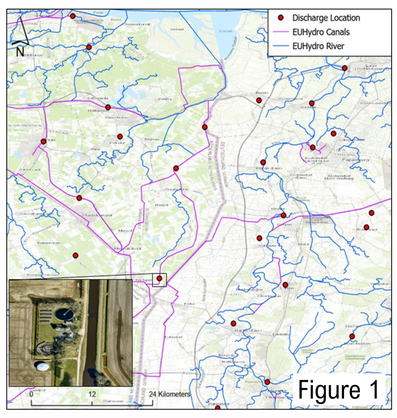


Figure 1

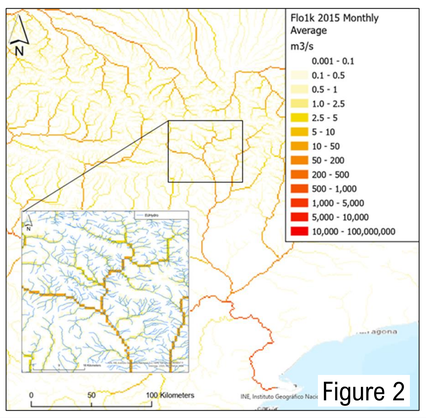


Figure 2

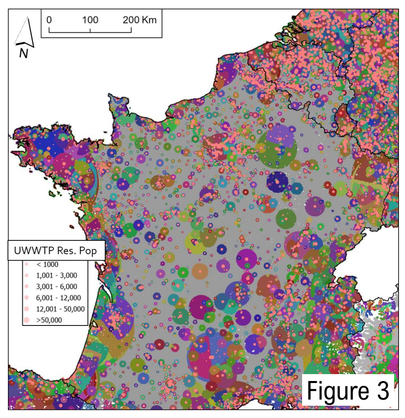


Figure 3

Figure 3. Colored areas represent individual sewersheds and grey areas are unconnected population (1km gridded data).

Figure 4. A: Density of connected (blue) and unconnected (grey) population (people/km^2) in region. B: % population connected to UWWTP in region (mapped as center 1km^2 grid cell). Yellow box represents 200x200km region size.

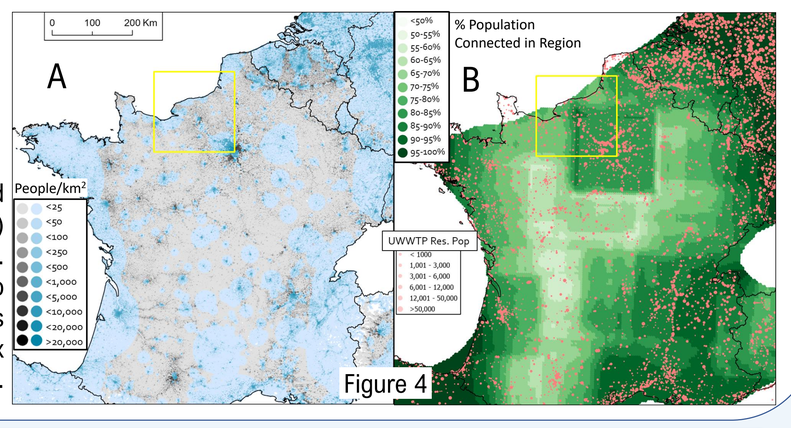
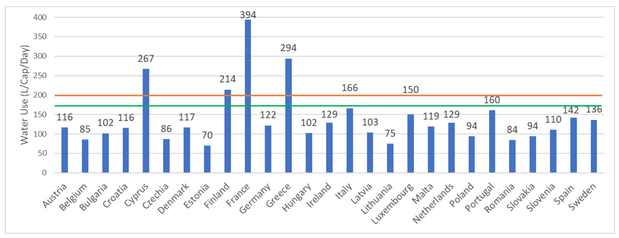
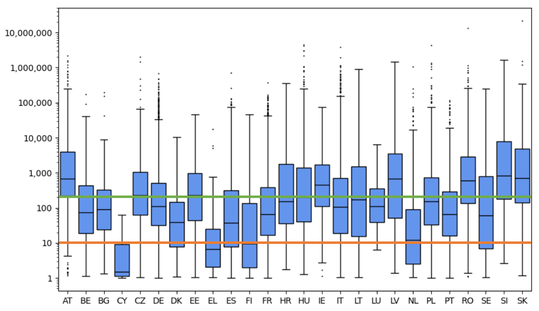


Figure 4

EUSES Context



Household water use by country ranges 70 to 394 L/cap/day with a population weighted average of **171 L/cap/day** (green line) compared to EUSES default of **200 L/cap/day** (orange line).

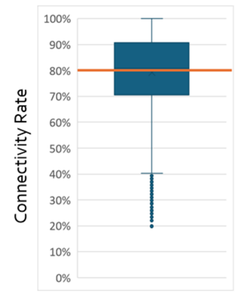


Across the 19,917 UWWTPs in the EU-27 the median **dilution factor** was **110** (green line) and the lower 10th percentile was **5.1** using the 1986-2015 long term annual mean flow. EUSES default dilution factor of **10** (orange line) corresponds to the **16th %ile** of the EU-27 distribution.

Percentile	Population / km²	Region population (million) for 100% land (40,000 km²)
25%	39	1.6
50%	**82**	**3.3**
75%	143	5.7
90%	218	8.7
95%	300	12.0
99%	488	19.5
99.1%	**500**	**20.0**

Using the "moving window" approach (Fig. 4) the median 200x200km window contains **82 persons/km^2**, or **3.28 million people** (for 100% land area). The EUSES default of **20 million people**, or **500 persons/km^2**, represents the **99.1st %ile** of the 160,566 windows.

Percentile	Connectivity Rate
25%	71%
48%	**80%**
50%	**81%**
75%	91%
90%	98%
95%	100%



EUSES assumes that **80%** of the population is **connected to a WWTP** for the 200x200km region. Country-level data ranges between 53% to100%, with a **population weighted average of 83%.** Based on the "moving window" approach, the EU-27 **median value was 81%**.

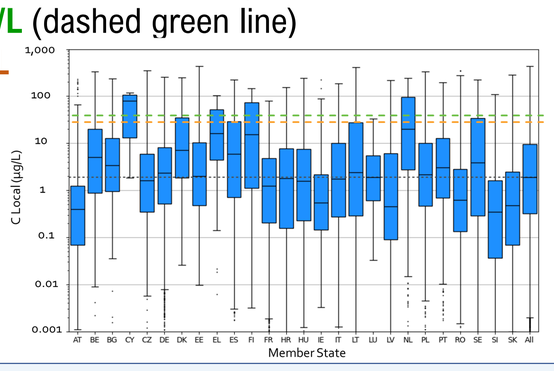
Case Study - Linear Alkylbenzene Sulphonate (LAS)

EUSES model - Based on a per capita use rate of 3.18 g/cap/day and a 99% WWTP removal rate (HERA, 2013):

	$PEC_{regional}$	C_{local}	PEC_{local}
LAS Concentration (µg/L)	1.17	**29.4**	30.5

ERASM *Spatialized C_{local} Model* - EU-27 distribution for LAS:

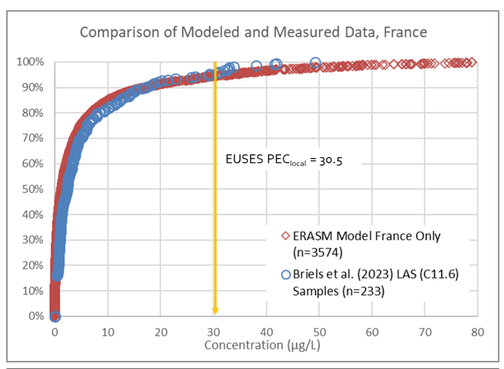
- Median C_{local} = **1.9 µg/L** (dashed black line)
- 90th %ile C_{local} = **39.9 µg/L** (dashed green line)
- EUSES C_{local} of **29.4 µg/L** (dashed orange line) is the **87th %ile** of the ERASM model distribution



ERASM *Spatialized C_{local} Model* Comparison to Measured Data

France

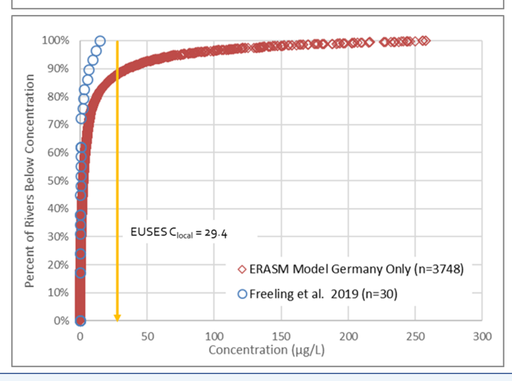
- 233 **measured** river concentrations median value of **2.4 µg/L** and a 90th %ile of **17.0 µg/L**
- 3574 **modeled** river concentrations median value of **1.2 µg/L** and a 90th %ile of **16.9 µg/L** (includes $PEC_{regional}$)
- EUSES corresponds to the **95.6th %ile** of the measured and **94.6th %ile** of modeled



%ile	Modeled (µg/L)	Measured (µg/L)
25	0.2	0.8
Median	**1.2**	**2.4**
75	4.7	6.1
90	**16.9**	**17.0**
95	32.8	29.1
99	60.5	40.5
Max	80.1	49.3
94.6	**30.5**	-
95.6	-	**30.5**

Germany

- 30 **reported** concentrations median value of **0.3 µg/L** and a 90th %ile of **7.6 µg/L**
- 3748 **modelled** local concentrations median value of **2.3 µg/L** and a 90th %ile of **34.9 µg/L**
- EUSES **exceeds all** measured values and is the **88th %ile** of modeled values



% ile	Modeled (µg/L)	Measured (µg/L)
25	0.5	0.1
Median	**2.3**	**0.3**
75	8.2	1.0
88	**29.4**	-
90	**34.9**	**7.6**
95	75.1	11.2
99	191.7	14.1
Max	257.6	14.8

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Work supported by ERASM

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