Great Britain–Specific Environmental Exposure Scenarios for Chemicals in EUSES

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Background

The primary environmental exposure model used in UK REACH is EUSES, which was developed more than 20 years ago to serve the purposes of the European Union (EU). A previous scoping study for the Environment Agency in 2018 identified several potential changes and updates to EUSES, including targeted parameterisation to make the outputs more useful and relevant to UK REACH stakeholders, particularly regulatory agencies.

In this work key environmental parameters within EUSES were identified which could be altered to be more specific to Great Britain (GB). A sensitivity analysis has been conducted to identify GB-specific parameters which have the most impact on the predicted environmental concentrations (PECs) derived in the exposure model compared to the standard EUSES model.

Methods

Setup GB-EUSES Model

- The EUSES model v2.1.2 was selected to adapt default settings to develop GB-specific version of the model.
- Relevant default parameters were identified (see Figure 1) and values were replaced by available data found in the peer-reviewed and grey literature.

Sensitivity analysis

- A sensitivity analysis (Sobol) was performed to identify the parameters that have the largest impacts, relative to the other parameters, on Predicted Environmental Concentrations (PECs) obtained.
    1. GB-specific EUSES vs Standard EUSES
    2. Sensitivity of GB-EUSES to the different GB-specific parameters
- The sensitivity analysis was performed using four hypothetical chemicals with varying physico/chemical properties (solubility, vapour pressure, log Kow). PECs were estimated for all substances based on a standard release of 1 kg/d to waste water and air at the local, regional and continental scales.

Results

Setup GB-EUSES Model

Characterisation of compartments
Updated parameters
- Environmental temperature
- Characteristics in soil (e.g., volume fraction of solids/water/air; weight fraction of organic carbon/matter)

Release estimation
Updated parameter
- Fraction connected to sewer system

Sewage treatment
Updated parameters
- Sewage flow
- Number of inhabitants feeding one STP
- Effluent discharge rate of local STP
- Number of inhabitants of region/continent
- Windspeed in the system

Local distribution
Updated parameters
- Dilution factor (rivers)
- Flow rate of receiving water
- Mixing depth of grassland soil
- Dry sludge application rate
- Mixing depth of agricultural soil
- Average annual precipitation

Humans
Updated parameters
- Daily intake of fish/leaf crops/root crops/meat/dairy products

Regional and continental distribution

Continental scale
Great Britian

Regional Scale
Aire-Calder catchment

Updated parameters
- Number of inhabitants
- Area (land+rivers/sea)
- Area fraction of freshwater, natural soil, agricultural soil, industrial/urban soil
- Environmental temperature
- Windspeed in the system
- Average precipitation

- GB-specific values for the listed parameters were included in the model.
- A list containing the GB-specific values can be found here[1].
- For the remaining parameters, the standard EUSES default values were kept.

Figure 1. Overview of the EUSES input parameters for which the default values were replaced by Great Britain-specific values. The centre screenshot displays the Defaults input screen from EUSES 2.1.2.
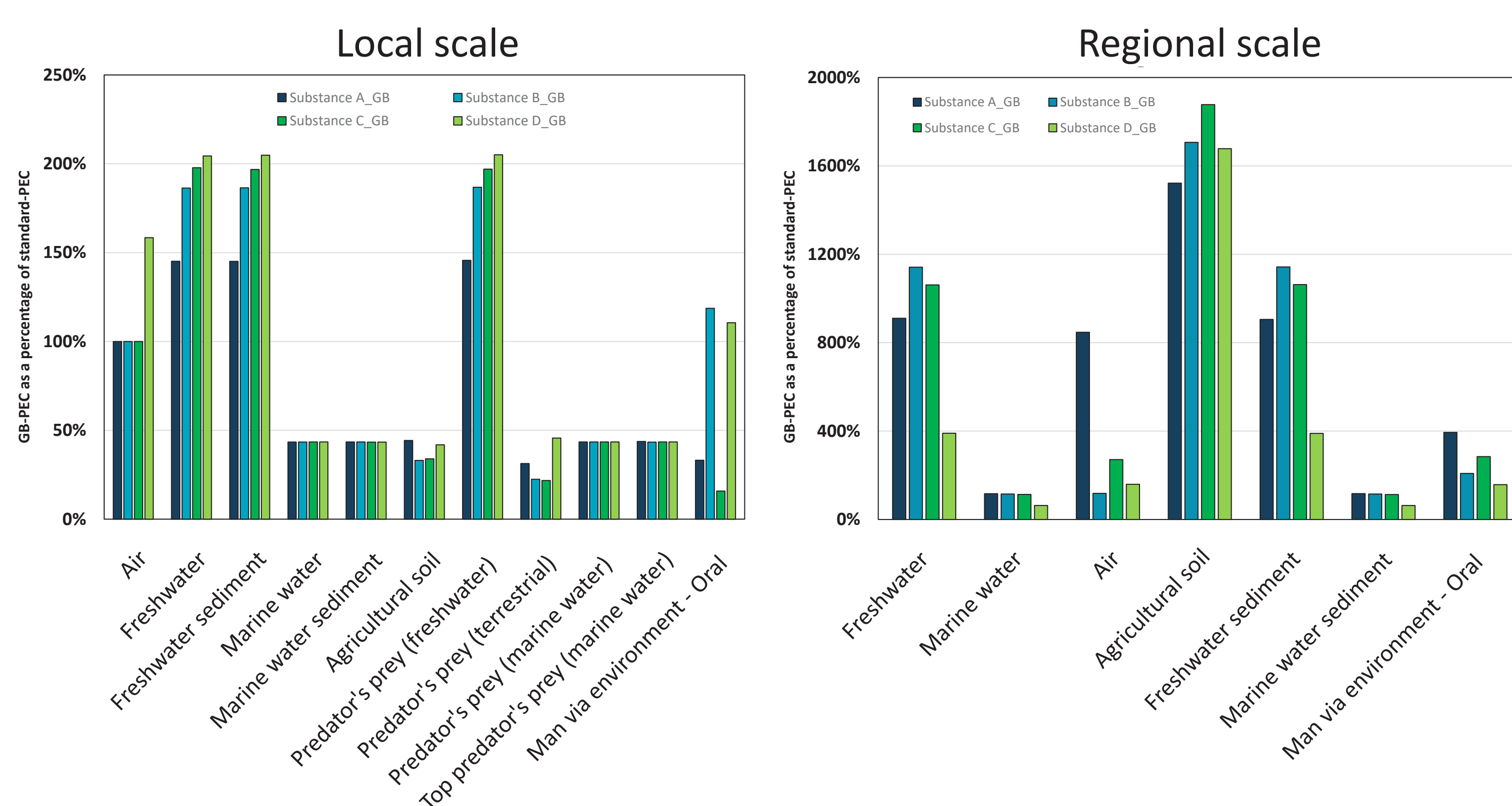
GB-EUSES vs Standard EUSES

Figure 2. Local scale PECs (left plot) and regional scale PECs (right plot) estimated using the GB-specific parameters as a percentage of the PECs estimated using the standard EUSES parameters.

Local scale
- Local scale PECs for air were similar between the 2 models; freshwater-related PECs were higher in GB-EUSES; marine water-related PECs and soil-related PECs were lower in the GB-EUSES model.
- GB-EUSES PECs were consistent among the different substances.

Regional scale
- Freshwater, freshwater sediment, soil and MvE-oral PECs are higher in GB-EUSES → result from higher mass loading for GB regional area vs Standard EUSES region.
- Marine water and marine water sediment have similar PECs → same compartment area in GB-EUSES and Standard EUSES.

Sensitivity of GB-EUSES to the different GB-specific parameters

Parameters having the largest influence on PECs for water, sediment, soil, secondary poisoning.

Table 1. EUSES default and GB-specific values for the most influential input parameters on predicted environmental concentrations.

	Parameter	EUSES default value	GB-Specific value	Unit
Local scale	Number of inhabitants feeding one STP	1.0E+04	1.68E+04[2]	Population eq.
	Dilution factor for freshwater	10	3[3]	
	Sewage flow rate per inhabitant	200	274[2]	L. population equivalent^{-1}. d^{-1}
	Bulk density wet soil	1700	1500[4]	kg wet weight.m^{-3}
	Dry sludge application rate on agricultural soil	5000	3650[5]/5000[6]*	kg.ha^{-1}. year^{-1}
Regional scale	Windspeed in the system	3	4.7[7]	m.s^{-1}
	Area (land + rivers) of regional system	40,000	1960[3]	km^2
	Average precipitation, regional system	700	1172[8]	mm.year^{-1}
	Fraction connected to sewer system	80	98[9]	%
	Area fraction of freshwater, region (excluding sea)	0.03	0.029[10]	-

* The application rate of 3650 kg.ha^{-1}. year^{-1} is based on 1999 data; recent data shows an application rate of 5000 kg.ha^{-1}. year^{-1} but no distinction was made between agricultural land and grassland

Key findings

- A GB-specific version of the default values for the EUSES model was developed containing GB-specific values for 47 input parameters.
- Local scale PECs generated with GB-EUSES default values were generally within a factor of 2 (higher or lower depending on compartment) compared to standard EUSES.
    → Influential parameters in estimating GB-specific PECs included dilution factor, size and flow of STP, sludge application rate and soil density.
- Regional scale PECs generated with GB-EUSES were generally higher (up to 1900% of the value) compared to standard EUSES.
    → In practice, the differences in the regional scale will be smaller as GB regional tonnages and releases are likely to be lower than EU regional tonnages and releases.
    → Influential parameters in estimating GB-specific PECs included windspeed, precipitation rate and connection rate to sewage treatment.

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