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Joint RAC-SEAC Workshop on Impact Assessment:

"Approaches for translating the results of environmental risk assessment for use in socioeconomic impact assessment under REACH"

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Life Cycle Impact Analysis (LCIA)

Dean Leverett
wca environment ltd.

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Overview

- Objectives of ‘rapid assessment’
- Life Cycle Analysis
- Life Cycle Impact Analysis
  - Models
  - Impact descriptors
  - Uncertainties
- Case study
- Conclusions

Objectives

- To translate the 'risk' of a chemical into an 'impact'
- Incorporate uncertainty.
- To allow comparisons between different chemicals and Risk Management Measures (RMMs).
  - Evaluation of potential alternatives

Life Cycle Analysis

- Technique for modelling the (often complex) interactions between a ‘product’ and the environment
- Covers all stages of the production of a process (raw materials, processing, manufacture, distribution, use, repair & disposal)

Life Cycle Analysis

1. Planning

- Objectives, product definition, environmental parameters, evaluation methods and strategy for data collection

2. Screening

- Preliminary execution of the LCA and adjustment of plan

3. Data collection & treatment

- Undertaking measurements and calculations

4. Evaluation

- Impact categories, normalisation and weighting

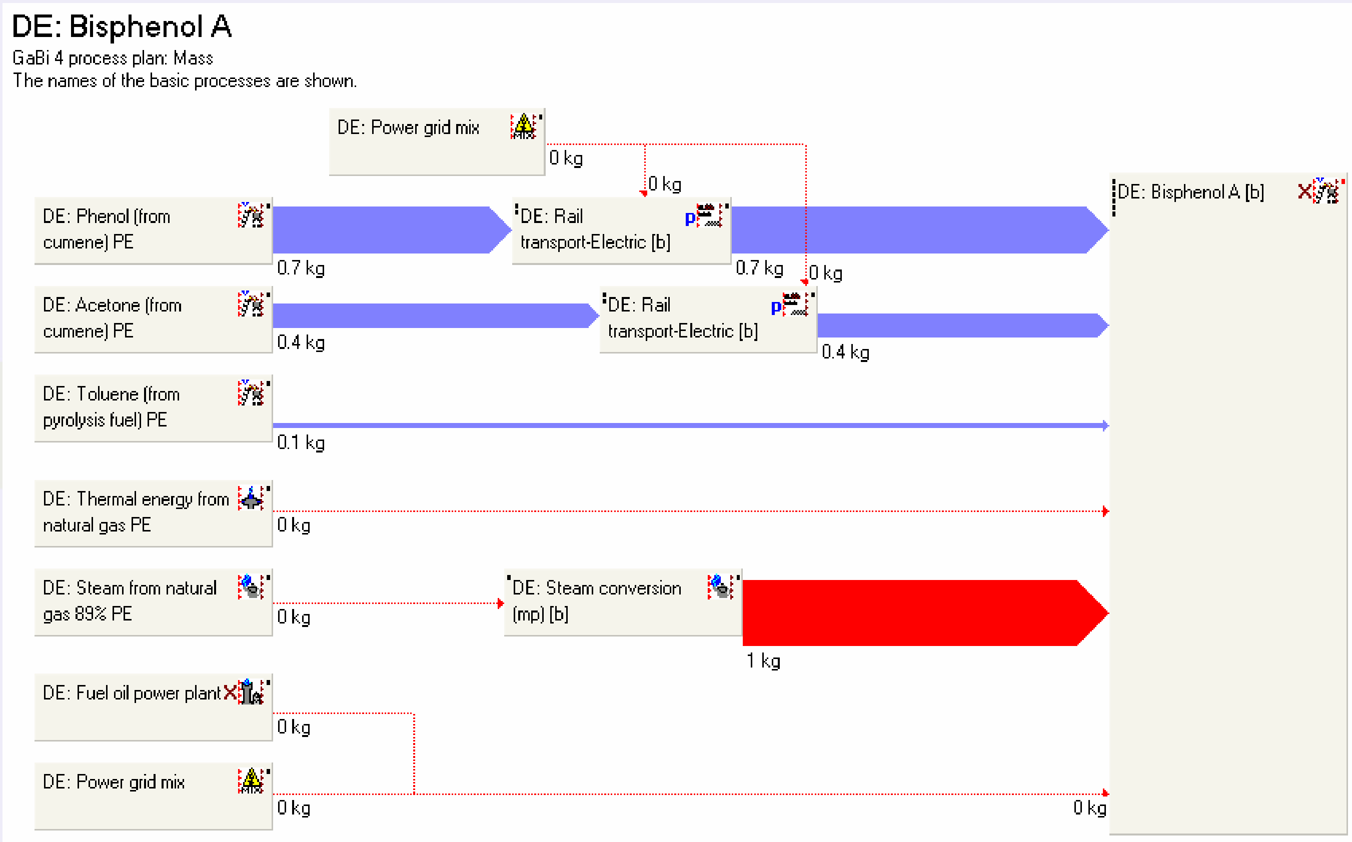
5. Interpretation

- Uncertainty and feasibility analysis

Life Cycle Analysis

- Quality of information in inventory table is critical
- Comparison between products only possible if data of equivalent quantity/ quality are available
- Not every factor contributing to impact can be reduced to a value for insertion in a model
- Data from generic processes, averages, unrepresentative sampling or outdated information will increase uncertainty of outputs and may render entire analysis flawed.

Life Cycle Analysis



Life Cycle Impact Analysis

- LCIA models provide a broader range of ecological impacts than conventional LCA
- Estimate contributions from various stages of life cycle to environmental impact categories
  - E.g. global warming, acidification, ecotoxicity

LCIA

- LCA parameters (e.g. emissions) are evaluated against impact categories using a specific LCIA model
- Quantitative outputs indicate degree of impact in each category
- This can be followed by;
  - Normalisation (equalisation of parameters)
  - Weighting (ranking of parameters)
  - provide basis for comparisons and usually incorporated into overall impact model

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Impact Modelling

- LCIA models have been developed which cover a range of environmental impact categories and emission scenarios
  - Freshwater, marine, terrestrial
- Impact values can be compared across impact categories, emissions and substances
- Depending on the model applied, impact may be expressed as:
  - Proportion of species or media affected
  - Normalisation of effect and exposure against a 'standard' substance

LCIA Models

- **CML - Institute of Environmental Sciences (CML), Leiden University**
  - Level of impact relative to that imposed by a kilogram of dichlorobenzene
- **Eco-Indicator 1995 & 1999 - Pré consultants**
  - "Potentially Disappeared Fraction" (PDF) of species attributable to an environmental load is multiplied by the size of the area of impact (m^2) and the likely exposure period (t)
- **EDIP (Environmental Development of Industrial Products) - Technical University of Denmark**
  - the volume of an environmental compartment affected (e.g. m^3 of water)
- **Impact 2002+ - University of Michigan**
  - level of impact relative to that imposed by a kilogram of reference substance
- **Environmental Impact Point (EIP or UBP method) - BUWAL, Switzerland**
  - "eco-factor" value, which ranks the effects in terms of their magnitude.
- **TRACI (Tool for the Reduction and Assessment of Chemical and other Environmental Impacts - US EPA**
  - impact relative to that imposed by a kilogram of 2,4-dichlorophenoxyacetic acid

Impact Modelling Limitations

- 'Black Box Approach'
  - The actual calculations performed within each model are not transparent .
  - While LCA software (e.g. GaBi 4) can be used by the non-expert to derive impacts, this provides no information on how the values were generated.
- The list of modelled substances available within each model is limited
  - Substances of interest may not (yet) have been modelled.
  - Development of new life-cycle data for a chemical is not expected to be a trivial exercise.

Impact Modelling Limitations

- Comparisons between impact categories & substances can only be made using the same model
  - So both substances to be compared must be available within the same model and impact categories.
- The models use the same input parameters and assumptions for hazard and risk as conventional ERA e.g. PNEC based on laboratory tests and modelled exposure
- Uncertainties and lack of equivalency between substances inherent in conventional ERA may also affect comparisons between chemicals using LCIA

Approach

- Concerned with impacts of a single substance from a particular use NOT whole life cycle
- Critical input parameter is volume of emission of a substance in a specific emission scenario (e.g. regional emission to freshwater)
- Gabi 4 LCA software used to ‘run’ each model for a substance (and its potential alternatives) and derive impact values based on emission volume
  - Contains the latest versions of the LCIA models (and accompanying chemical databases)

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GaBi 4 Impact Assessment

Chromium +VI [Heavy metals to fresh water] -- DB Flow

Object Edit View Help

Name: Chromium +VI

LCA | LCC

Addition:

Chemical formula: Cr6+

Reference quantity: Mass

CAS Code: 18540-29-9

Basis:

Comment/ Synonyms:

Quantity	1 kg = *	Unit	Standard deviation	1 [Quantity] = * kg
CML2001, Freshwater Aquatic Ecotoxicity Pot. (FAETP inf.)	27.656	kg DCB-Equiv.	0 %	0.036159
CML2001, Human Toxicity Potential (HTP inf.)	3.4204	kg DCB-Equiv.	0 %	0.29236
CML2001, Marine Aquatic Ecotoxicity Pot. (MAETP inf.)	3443.7	kg DCB-Equiv.	0 %	0.00029038
CML2001, Terrestric Ecotoxicity Potential (TETP inf.)	2.272E-019	kg DCB-Equiv.	0 %	4.4015E018
CML96, Aquatic ecotoxicity potential (AETP)	84	kg DCB-Equiv.	0 %	0.011905
CML96, Human toxicity potential (HTP)	67000	kg DCB-Equiv.	0 %	1.4925E-005
CML96, Terrestric ecotoxicity potential (TETP)	1.1E-005	kg DCB-Equiv.	0 %	90909
EDIP 1997, Ecotoxicity water acute	66667	m3 water	0 %	1.5E-005
EDIP 1997, Ecotoxicity water chronic	6.6667E005	m3 water	0 %	1.5E-006
EDIP 1997, Human toxicity water	18241	m3 water	0 %	5.4822E-005
EI99, EA, Ecosystem quality, Ecotoxicity	68.7	PDF*m2*a	0 %	0.014556
EI99, EA, Human health, Carcinogenic effects	8.26E-010	DALY	0 %	1.2107E009
EI99, HA, Ecosystem quality, Ecotoxicity	68.7	PDF*m2*a	0 %	0.014556
EI99, HA, Human health, Carcinogenic effects	8.26E-010	DALY	0 %	1.2107E009
EI99, IA, Ecosystem quality, Ecotoxicity	55.4	PDF*m2*a	0 %	0.018051
EI99, IA, Human health, Carcinogenic effects	4.27E-010	DALY	0 %	2.3419E009
I02+ v2.1 - Non-carcinogens - Midpoint	2.6595	kg C2H3Cl-Eq. to air	0 %	0.37601
TRACI, Ecotoxcity Water	780.91	kg 2,4-Dichlorophenoxyace	0 %	0.0012805
TRACI, Human Health Cancer Water	5.5818E-046	kg Benzene-Equiv.	0 %	1.7915E045
TRACI, Human Health Non Cancer Water	583.21	kg Toluene-Equiv.	0 %	0.0017146
UBP, Ecological scarcity method	6.6E005	UBP	0 %	1.5152E-006

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1,2,4 trichlorobenzene

Methodology	Emissions to seawater (1kg =)		Unit
	1,2,4 TCB	MCB	
CML 2001 Freshwater Aquatic Ecotoxicity Potential	0.0043792	0.0002586	kg Dichlorobenzene equivalents
CML 2001 Marine Aquatic Ecotoxicity Potential	3.1293	0.35096	kg Dichlorobenzene equivalents
CML 2001 Terrestrial Ecotoxicity Potential	0.0039631	0.0004101	kg Dichlorobenzene equivalents
TRACI Ecotoxicity Water	43.685	8.8594	kg 2,4-Dichlorophenoxyacetic acid

1,2,4 trichlorobenzene

- On a per kg basis, emissions of MCB to seawater appear to result in less environmental impact than emissions of 1,2,4-TCB.
- The final impact statistics also depend on the amount of each substance likely to be emitted under each scenario.
- Between 4.9 and 17 kg of MCB would need to be emitted to seawater to result in a similar impact as the release of 1 kg of 1,2,4-TCB.

Conclusions

- Application of LCIA within software such as GaBi 4 is a "black box" approach with limited transparency
  - although the core input parameters are conventional ecotoxicological hazard and exposure information.
- LCIA can be used to normalise the environment impact of chemical emissions and to express this impact in terms of equivalents which are potentially easier to visualise than traditional chemical risk assessment outputs.

Conclusions

- The application of LCIA approaches depends critically on the availability of data for the chemical of interest in LCIA models / chemical databases.
- This information is unlikely to be available for the majority of chemicals currently considered for Restrictions and Authorisations.
- It is unclear if there is sufficient time to develop the required data under the REACH SEA process.

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Conclusions

- LCIA be a useful tool for the comparison of impacts if used in a relative manner (i.e. to compare chemicals) and if the models can be developed to incorporate the specific substances of interest if;
- the overall level of uncertainty within each LCIA model can be kept fairly consistent
  - Modelling the impact of each substance using a number of different LCIA methodologies which serves to 'validate' the general results of each individual model and,
  - By using input parameters (e.g. emission data) that are of a comparable quality

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Contact us for further information

solutions@wca-environment.com

www.wca-environment.com

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