LEVERAGING LCA TO IMPROVE TUR

EFFORTS TO IMPROVE CHEMICAL TOXICITY ASSESSMENT IN LCA

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Tom Gloria, Ph.D.
Program Director, Sustainability

~120 Courses
~100 Instructors
70% PhDs or ScDs
97% have advanced degrees, including ALMs, FAIAs, JDs, MAs, MBAs, MEds, MDs, MSJs, MPAs,

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Key Learning Outcomes

General understanding of:

- Approach to Life Cycle Impact Assessment (LCIA)
- Current Practice – USEtox
- Recent advancements - CLiCC
- Q & A

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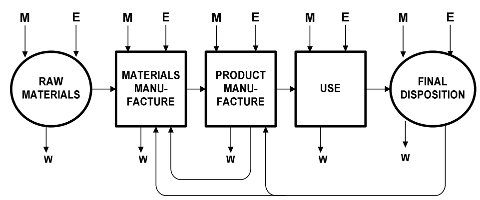
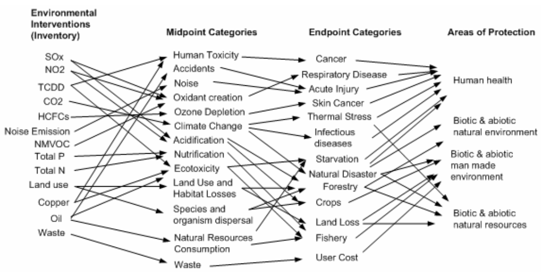
LCA ENVIRONMENTAL ACCOUNTING



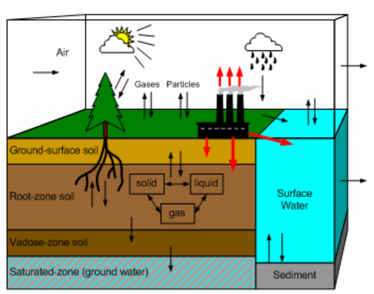
M = Materials
E = Energy
W = Wastes (air, water, & soil)

LCIA FRAMEWORK

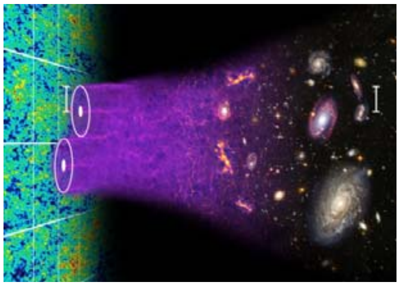


Adapted from Jolliet et al. (2004) The LCIA Midpoint-damage Framework of the UNEP/SETAC Life Cycle Initiative, *IJLCA* **9** (5) 394-404.

FATE AND TRANSPORT OF EVERYTHING!



MAPPING THE UNIVERSE!



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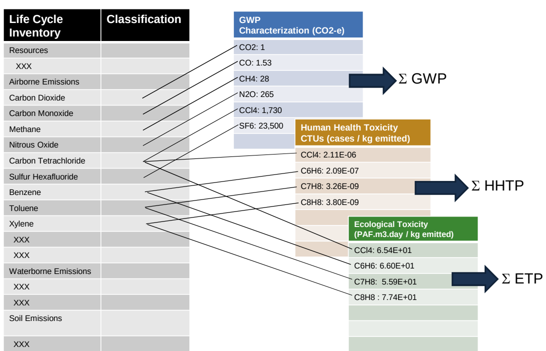
Princeton University: Sloan Digital Sky Survey www.sdss3.org

IMPACT ASSESSMENT



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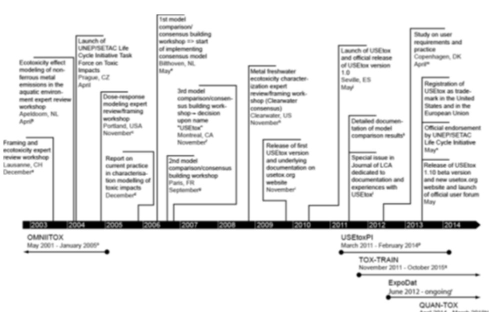
STORY OF USETOX



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Westh et al. (2015) The USEtox story: a survey of model developer visions and user requirements. IJLCA 20:299-310.

USETOX FRAMEWORK

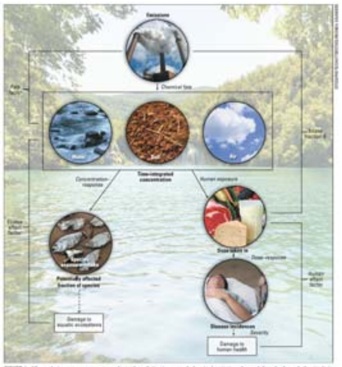


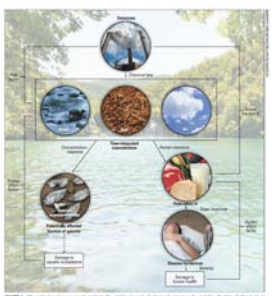
FIGURE 1. Life cycle impact assessments evaluate the relative impacts of chemical emissions by modeling the fate of chemicals in air, water, and soil and their potential toxic effects on humans and other living organisms.

Hauschild (2008) Building a Model Based on Scientific Consensus for Life Cycle Impact Assessment of Chemicals: The Search for Harmony and Parsimony ES&T 42:7032-7037

USETOX FRAMEWORK

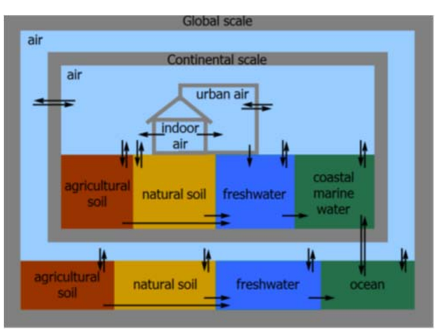
TABLE 1. Factors which were important for the different performance of the characterization models

Model component	Key factor	Parameter value (P) or algorithm choice (A)
Fate	Advection as a loss mechanism in some models	A
	Inclusion of the intermittent character of rain	A
	Residence times of media, particularly marine water, differ greatly	P
	Different algorithms used for estimation of partition coefficients	A
	Modeling of soil compartment: (i) homogeneous versus vertically layered soil compartment and (ii) generic versus division between agricultural, industrial and natural soils	A
Human exposure	Urban air compartment nested within continental air compartment	A
	Difference in population density on the urban and rural scale	P
	Different algorithms used for estimation of biotransfer and bioconcentration factors (fish, meat, milk, vegetation)	A
Human toxic effects	Some models extrapolate between intake routes (inhalation, ingestion, dermal)	A
	Models use different effect indicators (TD50, ADI, TD10)	P
Ecosystem effects	Models use different effect indicators (PNEC, HC50)	P
	Ocean modeled as a sink only (no effects considered)	A
	Some models use acute ecotoxicity indicator	P



Hauschild (2008) Building a Model Based on Scientific Consensus for Life Cycle Impact Assessment of Chemicals: The Search for Harmony and Parsimony ES&T 42:7032-7037

NESTED TRANSBOUNDARY MODEL



http://www.usetox.org/ 12

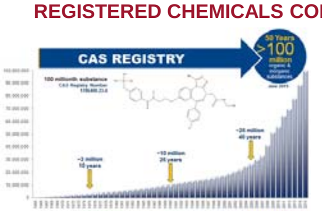
USETOX ACCEPTANCE & V.2 UPDATE

- Covers 3000+ ecotox and 1000+ HH Tox
- Endorsed by UNEP SETAC
- EC International Reference Life Cycle Data System
- US EPA TRACI Methodology
- Added for V2.1:
  - Residential and occupational indoor environments
  - Ionizing organic chemicals
  - Exposure to pesticides via food crop consumption
  - Generic freshwater ecotoxicity for metals
  - Continent (8) and sub-continent (17) specific landscape parameters

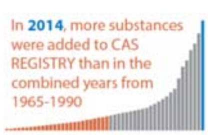
UNCERTAINTY & INTERPRETATION

- Characterization factors vary by 10^{15} magnitude
- Contributions of 1%, 5%, or 90% considered equal
- Very useful to identify the top 10 or 20 chemicals
- Chemicals contribution > 1/1000th to the total score
- "It is better to be vaguely right than exactly wrong" (Read 1920)

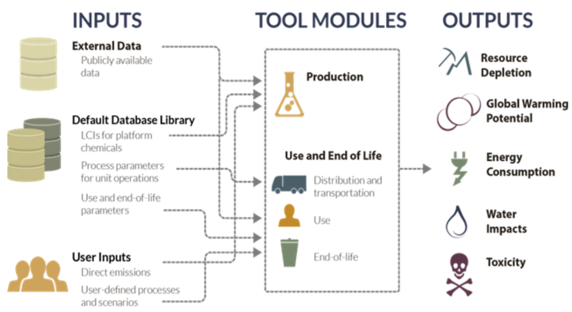
REGISTERED CHEMICALS CONTINUE TO GROW



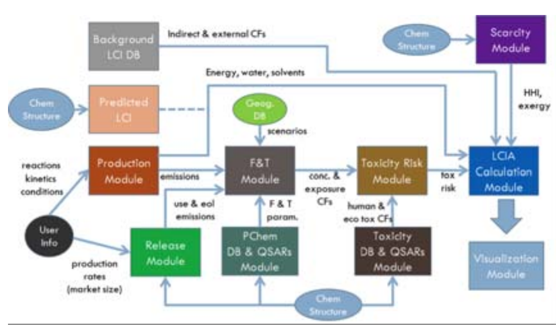
~15,000 Chemicals per day



CHEMICAL LIFE CYCLE COLLABORATIVE (CLICC)



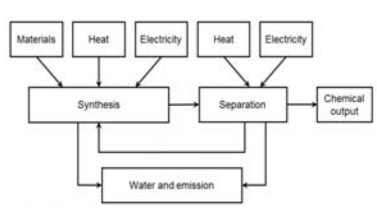
CHEMICAL LIFE CYCLE COLLABORATIVE (CLICC)



BUILD A BIGGER CHEMICAL C-TO-G LCI

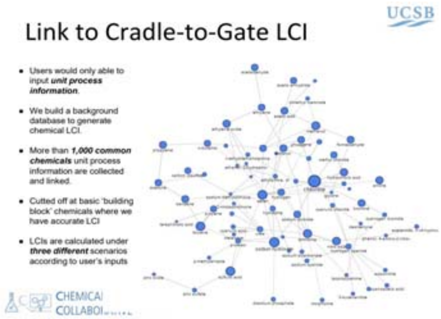
UCSB

LCI Modeling Framework



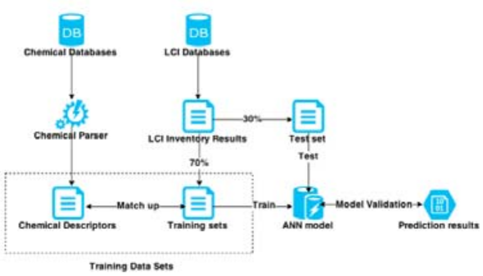
CHEMICAL LIFE CYCLE COLLABORATIVE

BUILD A BIGGER CHEMICAL C-TO-G LCI



https://clicc.ucsb.edu/sites/clicc.ucsb.edu/files/assets/2016_clicc_webinar_1.pdf

PREDICTIVE LIFE CYCLE INVENTORY MODULE



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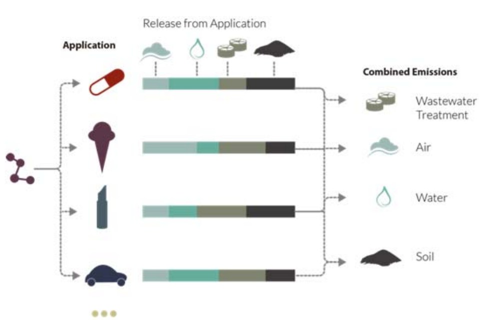
CHEMICAL RELEASE MODULE



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MARKET USE (CONFIDENTIAL)

Market Size Data (Samples)

Samples of market size data (numbers are not accurate due to confidentiality)

Product categories	Functional uses			
	Solvents	Surfactants	Biocides	Aerosol propellants
Paints & coatings	62.0%	3.0%	13.0%	17.0%
Printing inks	10.0%			
Pharmaceuticals	7.5%			
Cosmetics/Personal Care	3.5%	20.0%	12.0%	35.0%
Adhensives	2.5%			
Construction		4.0%		
Home care		45.0%		30.0%
Industrial & institutional cleaners		4.0%		
Food processing		3.5%		
Oilfield chemicals		4.0%		
Agricultural chemicals		4.0%	18.0%	
Textile		2.5%		
Water treatment			20.0%	
Food & beverage			21.0%	10.0%
Wood preservation			16.0%	
Medical				5.5%
Other	14.5%	10.0%		2.5%

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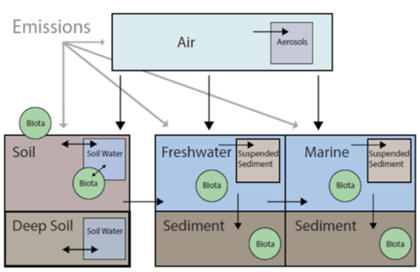
FATE AND TRANSPORT MODULE



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FATE AND TRANSPORT MODULE

CLiCC Fate & Transport Model	Other Models
• Mass balance model – Non-steady state model	• Steady-state
• Predicts time-dependent daily concentrations	• Output is average value at steady state
• Uses regionally specific climate data	• Low resolution
• Release scenario is fully customizable	• Rigid structure

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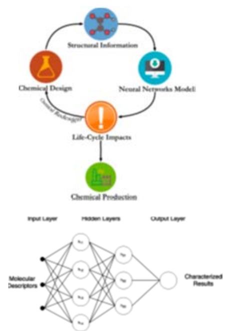
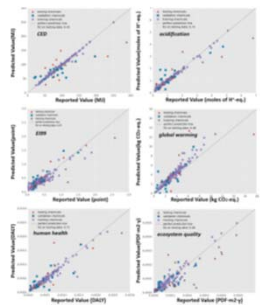
RAPID LCIA SCREENING – ARTIFICIAL NEURAL NETWORKS





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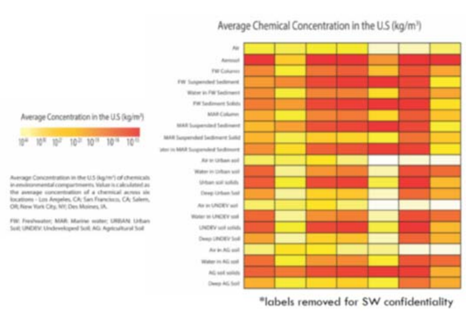
EXAMPLE OUTPUT



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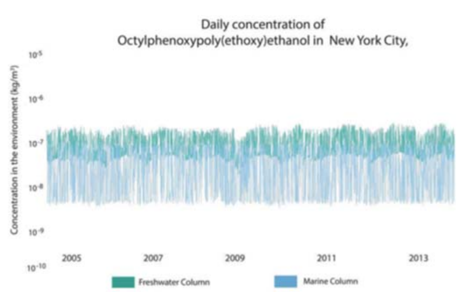
EXAMPLE OUTPUT



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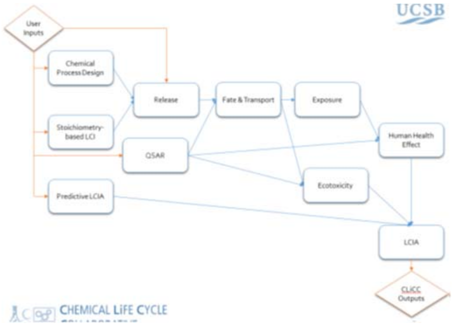
APPLICATION OF CLICC



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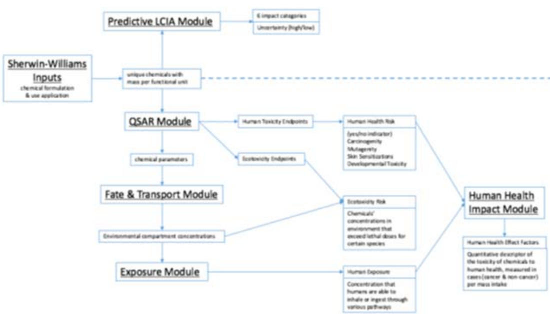

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SUMMARY

- USEtox most widely used toxicity model in LCA
  - Consensus approach
  - Continue to update
- Growing number of chemicals
  - Lack of CtG information
  - Lack of LCIA CF information
- CLiCC
  - Advancing LCI coverage
  - Dynamic Fate and Transport model
  - Advancing LCIA coverage (not just tox)
  - Imbedding uncertainty & sensitivity

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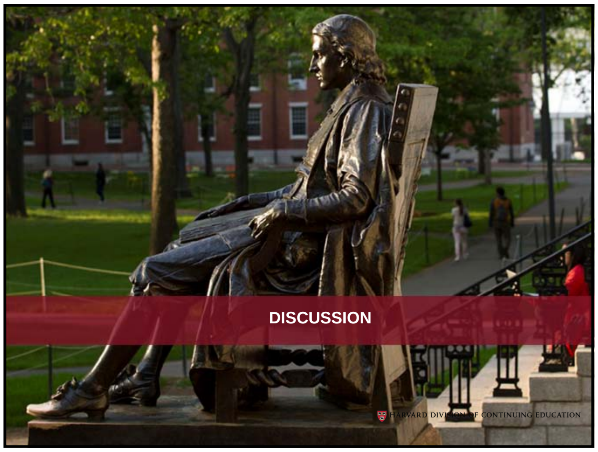
DISCUSSION