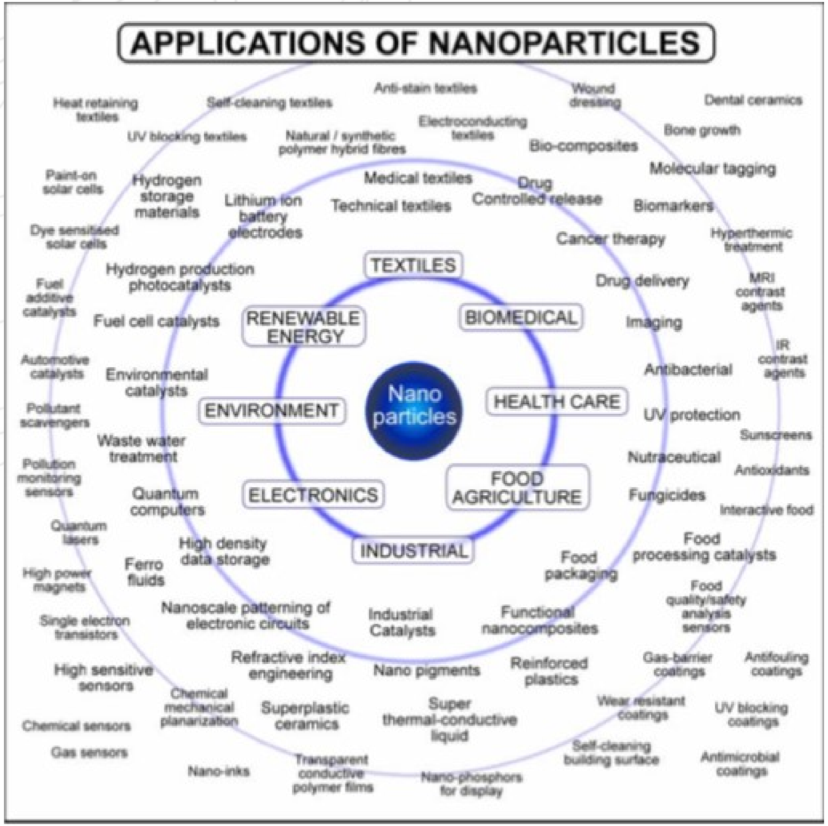
LCA and RA for nanotechnologies: complementarities and challenges

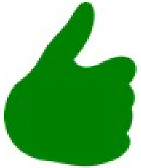
65th LCA Discussion Forum

Elorri Igos
Zürich, 24th May 2017

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY
LIST

INTRODUCTION





Improved performance, functionalities, reduction of hazardous substances

Are they safe for humans and ecosystems?

↓

Risk Assessment (RA)

Can they reduce the overall environmental impacts of products?

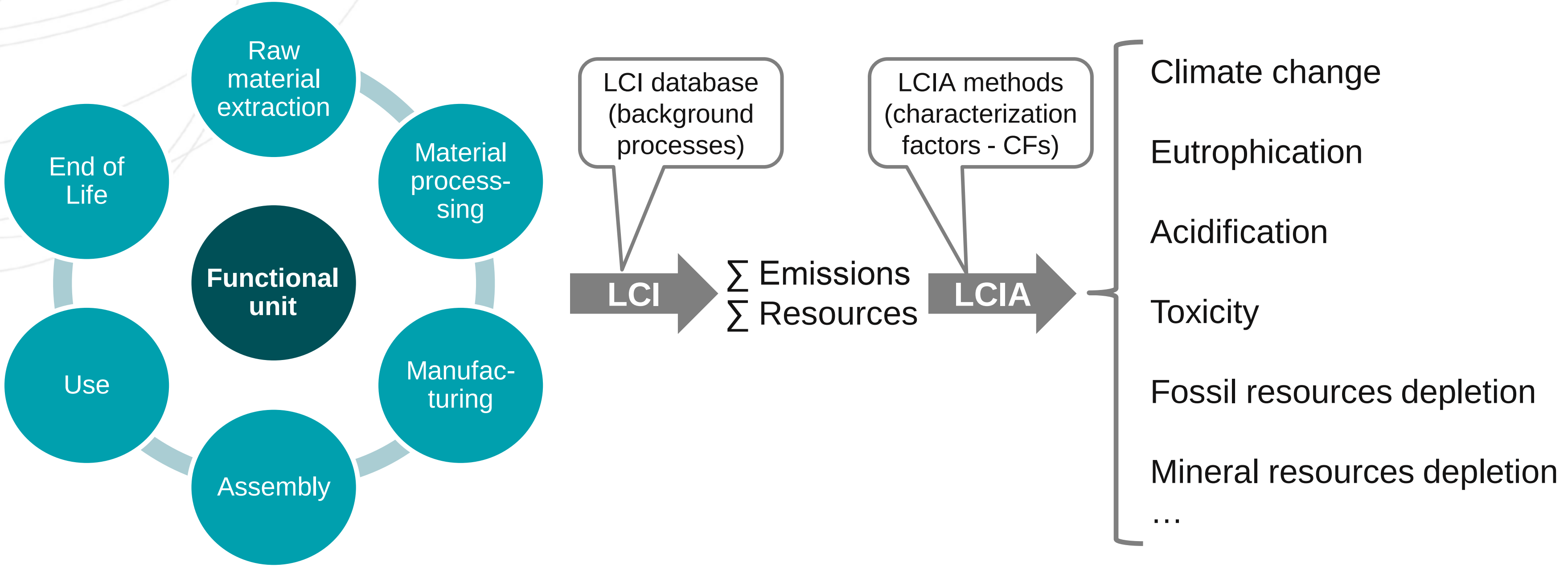
↓

Life Cycle Assessment (LCA)

Source: Tsuzuki et al. (2009), Int J Nanotechnol 6 (5/6)

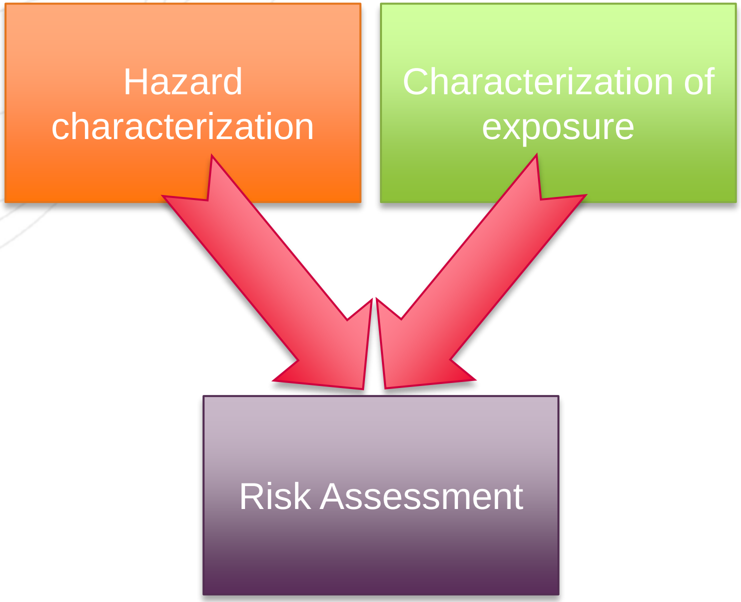
INTRODUCTION

LCA objective: Evaluate potential environmental impacts along the lifecycle of products or processes.



INTRODUCTION

RA objective: estimate qualitatively and quantitatively the risk related to a well-defined scenario and an identified hazard.



INTRODUCTION

	LCA	RA
Principle	Less is better	Above threshold
Indicators	Potential impacts	Actual risks
Scope	Life cycle perspective	Substances
Temporal and spatial scope	Mostly generic	Specific
Approach	Realistic estimates	Worst case scenario

Common history

- Toxicity LCIA methods rely on RA information (e.g. EUSES model, toxicity endpoints)
- LCA field part of SETAC since 1990

LCA AND RA COMBINATION
Review of applications

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

- Use RA to improve LCIA methods
  - Refine spatial and temporal dimensions
  - Integrate nonstandard operation scenarios, threshold values, disparate subpopulation effects, trophic transfer

Critical Review

Integrating Human Indoor Air Pollutant Exposure within Life Cycle Impact Assessment

STEFANIE HELLWEG,*,† EVANGELIA DEMOU,† RAFFAELLA BRUZZI,‡ ARJEN MEIJER,§ RALPH K. ROSENBAUM,‖ MARK A. J. HUIJBREGTS,⊥ AND THOMAS E. MCKONE#

RESEARCH AND ANALYSIS

An Approach to Integrating Occupational Safety and Health into Life Cycle Assessment

Development and Application of Work Environment Characterization Factors

Kelly A. Scanlon, Shannon M. Lloyd, George M. Gray, Royce A. Francis, and Peter LaPuma

Science of the Total Environment 408 (2010) 2817–2832

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

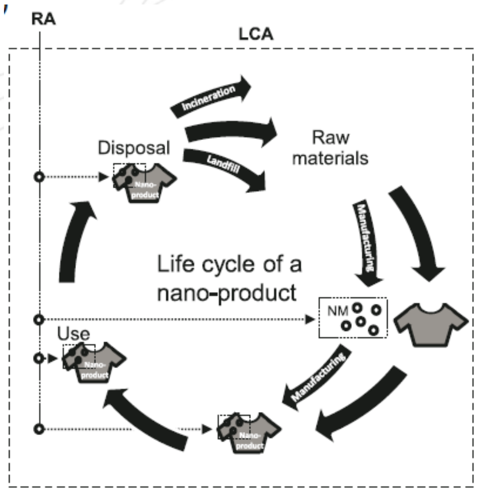
GLOBOX: A spatially differentiated global fate, intake and effect model for toxicity assessment in LCA

Anneke Wegener Sleeswijk*, Reinout Heijungs

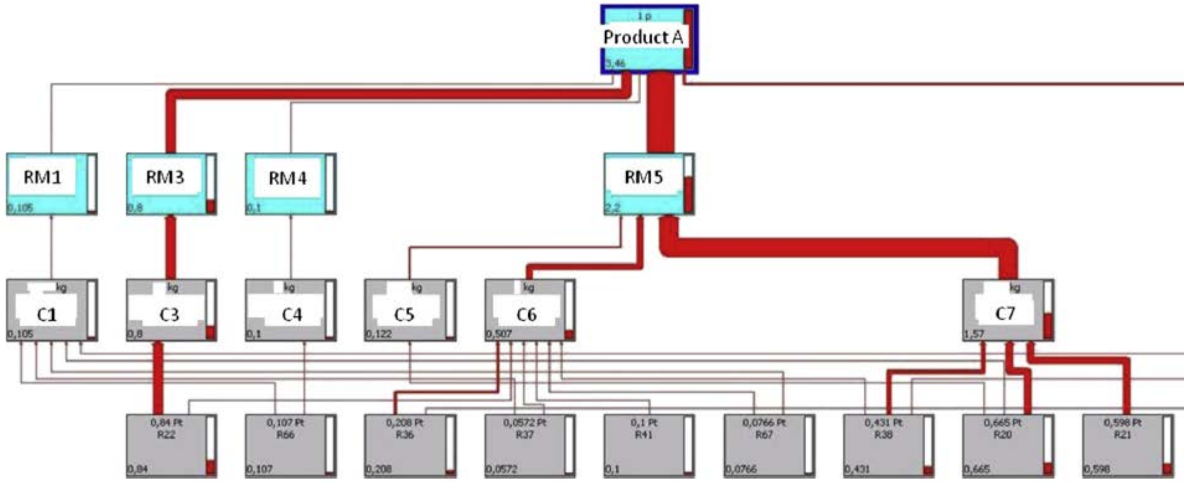
LCA AND RA COMBINATION
Review of applications

- Use RA to improve LCIA methods

- Include risk information into LCA study
  - Perform RA along product lifecycle (Grieger et al., 2012; Walser et al., 2013)
  - Track risk information (REACH) for the functional unit (Askham et al., 2013)



Source: Grieger et al. (2012), J Nanopart Res 14(958)

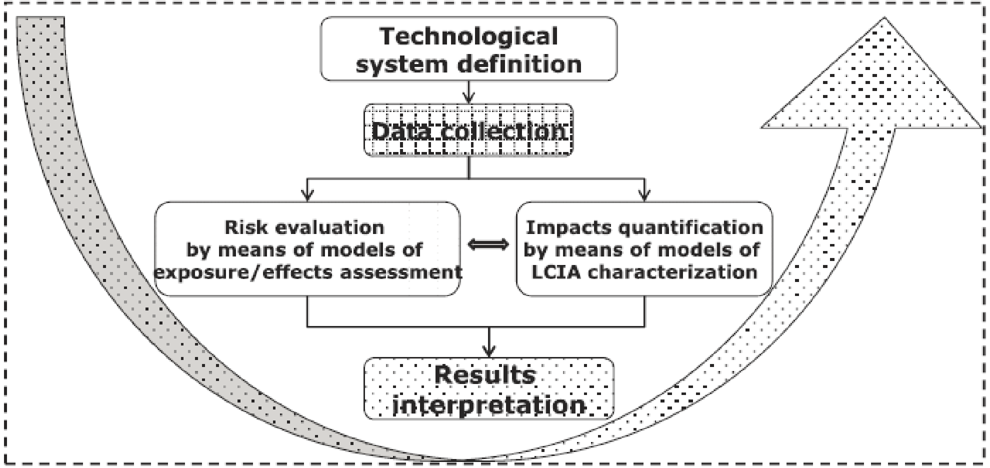


Source: Askham et al (2013), J Clean Prod 51

LCA AND RA COMBINATION
Review of applications

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY

- Use RA to improve LCIA methods
- Include risk information into LCA study
- Common framework for LCA and RA
  - Methodological framework based on common steps (Barberio et al., 2014)



Source: Barberio et al. (2014), Sci Tot Environ 496

LIST CONTRIBUTION
LiSRA Unit Presentation

- Life Cycle Sustainability And Risk Assessment (LiSRA) RDI Unit (32 researchers)

***Mission:** To provide industrial innovation and policy decision-making with science-based quantification of the impacts and risks of production and consumption patterns, to foster the transition towards a more sustainable society*

LIST CONTRIBUTION
LiSRA Unit Presentation

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY

We achieve our mission by providing public and private stakeholders with a **multidisciplinary, structured and user-centred platform** combining at different scales (from substances to products and large systems):

1) Integrated and reliable computational **Life Cycle Sustainability solutions**

2) Tools to support **environmental policy** development and implementation

3) Realistic and advanced 3-dimensional **in vitro models to evaluate hazards** with respect to human and environmental health

LIST CONTRIBUTION
LiSRA Unit Presentation

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

SMART CITIES

Prospective sustainability analysis towards circular economy

Quantifying the sustainability of policies and business decisions towards resource efficiency and circularity affecting large urban and natural systems, supply chains and markets

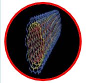
Betriber & Emwelt Entreprises & Environnement

SMART MANUFACTURING

Sustainable design of products and technologies

Quantiying the lifecycle sustainability of innovative products and technologies

REACH CLP



Prospective risk assessment of emerging substances

Science based assessment tools of (eco- and human-) toxicity of emerging chemicals, nanomaterials

Support R&I along the TRL scale

***For example**: Large scale consequential LCA of future implementation of mobility policies towards multi-modal e-mobility (including subsidies, infrastructure, user behaviour, …)*

***For example**: support discussion, definition and implementation of mobility policiers at country level*

***For example**: LCA comparison of electric vehicle vs. fossil fuel vehicle under specific scenarii (production, use, EOL)*

***For example**: anticipation of regulatory constraints / toxicity of currently non regulated substances regarding exhaust gases*

***For example**: assessing the human toxicity of dust emissions from diesel cars using the lung 3D in vitro model*

LIST CONTRIBUTION
In-vitro model development for NM

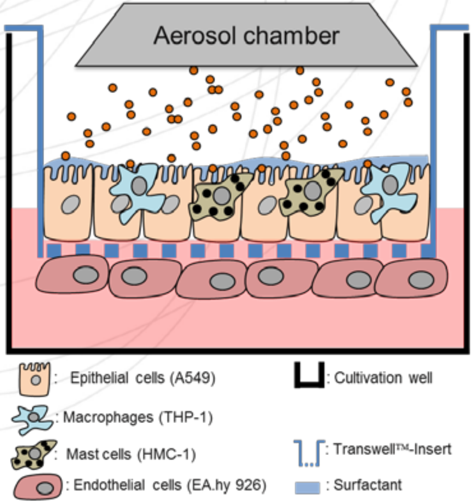
Challenges of NMs testing

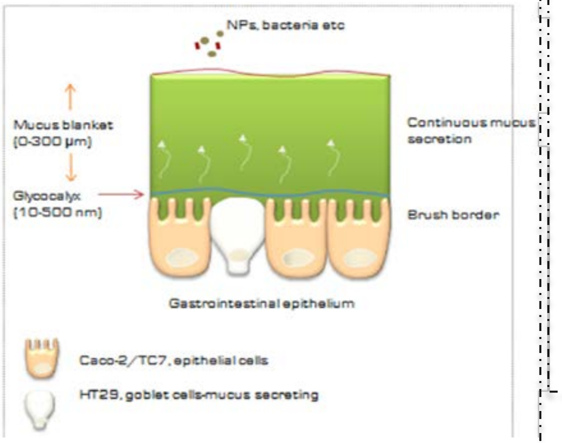
- High innovation potential → many new NMs produced and internalized in products
- Drawbacks of animal testing for new chemicals:
  - Ethical issues (3Rs principle – Replacement, Reduction and Refinement)
  - Long testing time
  - High cost
  - Skilled personnel and special facilities
- Testing guidelines for NMs still under development (mainly tailor-made approaches)
- Grouping and read-across strategies still under development

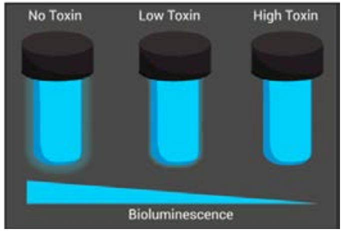
It is paramount to develop general strategies and methodologies that could allow fast and cheap testing of NMs, possible using animal-free assay

LIST CONTRIBUTION

In-vitro model development for NM







Bacteria

Micro algae

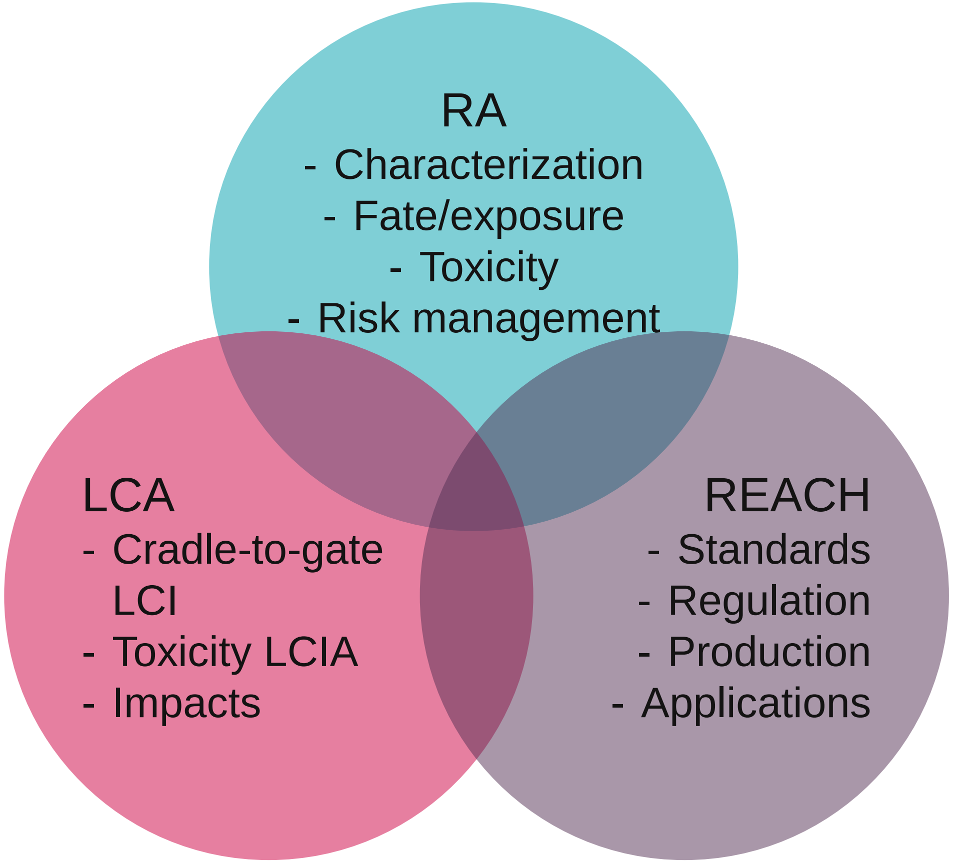
Gammarus sp.

Dapnia Sp.

Human health **Eco-toxicology**

LIST CONTRIBUTION
LiSRA framework for environmental support

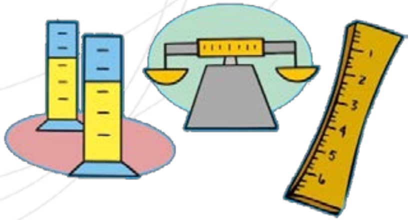
Coordination of research groups in relation with toxicity-related impacts



LCA AND RA FOR NANOTECHNOLOGIES

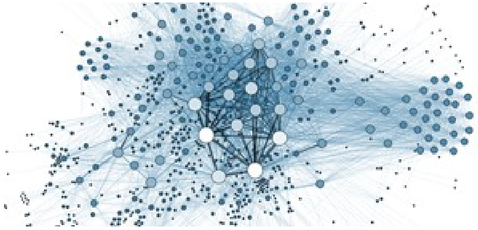
Nanotechnologies:

Difficulty of measurement and handling



Sensitive information

Complexity of modelling behaviour and toxicity effects



Lack of data for emissions of nanoparticles (LCI and PEC validation), for (eco)toxicity assessment (LCIA, exposure and hazard quantification), for production processes (LCI and RA)

Lack of understanding of properties influence, of fate mechanisms, of toxicity mechanisms (e.g. secondary target organs) (LCIA and RA)

LCA AND RA FOR NANOTECHNOLOGIES

How the combination of LCA and RA could better support decision makers?

Sharing knowledge to improve assessment

- Terminology (key properties, archetypes)
- Key mechanisms for fate, exposure and toxicity modelling
- Reliable toxicity data
- Information on production processes

Complementary results for decision makers

- Safety and potential impacts for humans and the environment
- Life cycle perspective
- Large panel of environmental effects

LCA AND RA FOR NANOTECHNOLOGIES

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

Key challenges for the application of LCA and RA for nanotechnologies:

- Correlation between NM properties and toxicity
- Exposure dose for toxicity tests
- Modelling effects of background
- Use and disposal scenarios
- Uncertainty treatment
- Standardisation and regulation

→ Collaboration between public authorities, research and companies

CONCLUSION

- There is a common background between LCA and RA

- LCA and RA combination:
  - Improve toxicity LCIA methods
  - Provide risk information along the life cycle of products
  - Provide complementary information to decision makers

- Numerous challenges for assessment of nanotechnologies, that could be more easily faced based on the collaboration of LCA and RA experts

- LCA and RA results should support the safe and eco-friendly deployment of nanotechnologies on the market

Thank you for your attention

elorri.igos@list.lu

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST