Redefining environmental nanomaterial flows: consequences of the regulatory nanomaterial definition on the results of environmental exposure models

Henning Wigger[1], Wendel Wohlleben[2], Bernd Nowack[1]

[1]Empa - Swiss Federal Laboratories for Materials Science and Technology
Environmental Risk Assessment and Management Group, Switzerland

[2] BASF SE, Dept. Material Physics, RAA/OR - B7, Ludwigshafen am Rhein, Germany

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From exposure to risk assessment of engineered nanomaterials (ENM)

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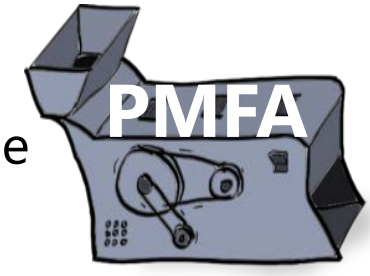
ENM production volume

Nano-enabled products

High uncertainties

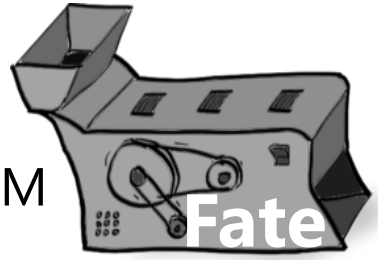
Product life cycle



Environmental release

AIM

Behavior of ENM



$$\text{Risk quotient}_{ENM} = \frac{\text{PEC}}{\text{PNEC}}$$

PEC = predicted environmental concentration
PNEC = predicted no-effect concentration
PMFA = probabilistic material flow analysis

Research objectives

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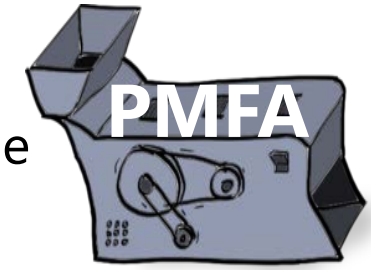
ENM production volume

Nano-enabled products

- **What is considered as an ENM?**

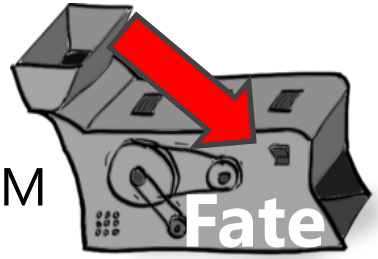
- **Where is it applied?**
- **In which amount (and form)?**

Product life cycle



Environmental release

Behavior of ENM



- **Which influence has the definition on the modeling results?**

$$\text{Risk quotient}_{ENM} = \frac{PEC}{PNEC}$$

PEC = predicted environmental concentration
PNEC = predicted no-effect concentration
PMFA = probabilistic material flow analysis

Approach

Estimation of production volume and its use

Definition of ENMs

Nanomaterial

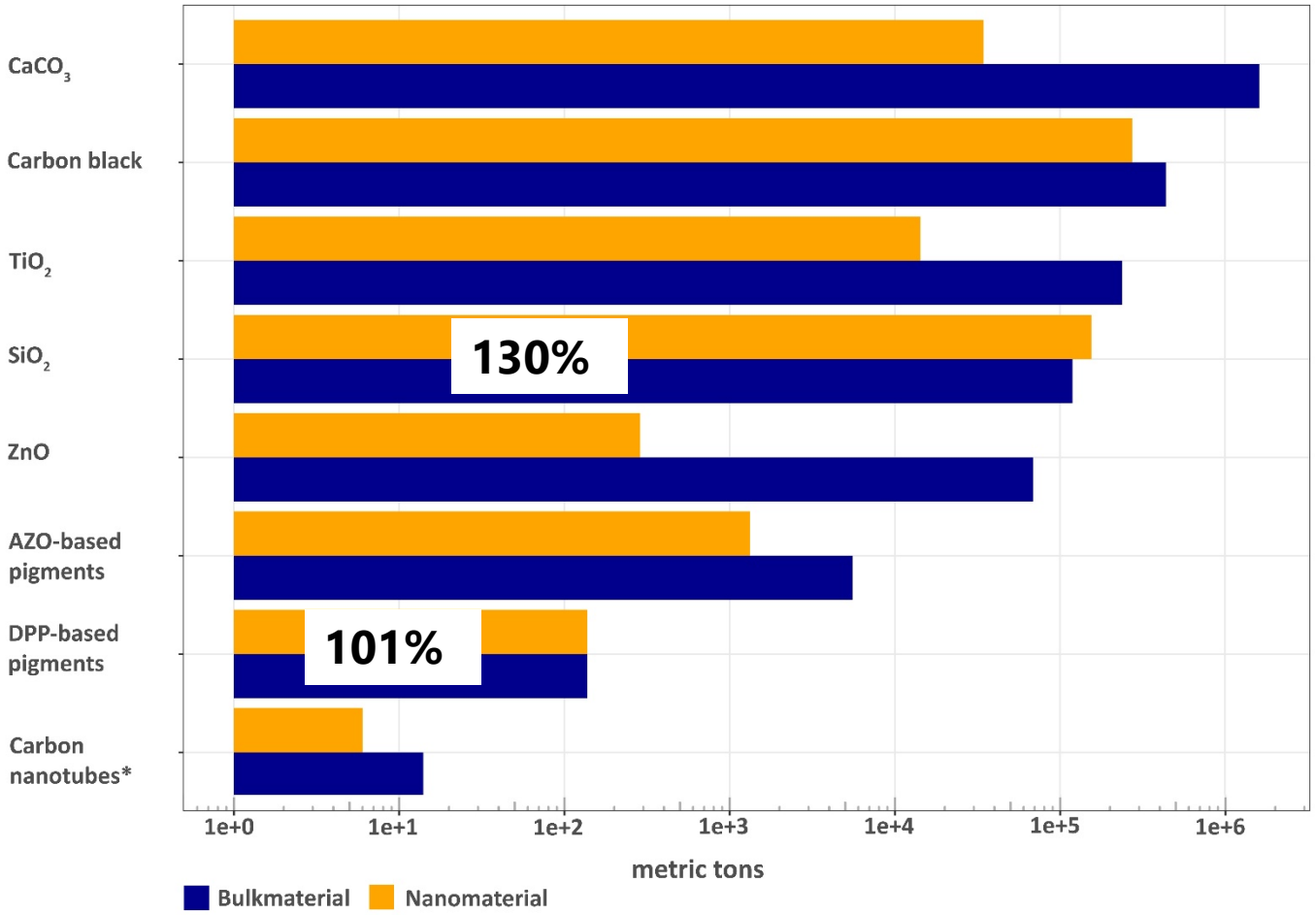
- Mandatory reporting
  - French report 2013

Bulkform

- market reports on World/European scale of the total production volume
  - Downscaling by a factor of French GDP/GWP

- Enable comparison of nano- to bulkmaterials
- Identify relabeled nano/bulkmaterials
- Use more detailed product categories based on market reports

Results –French inventory data on ENMs (2013) vs. downscaled market reports on bulk materials



- **Nano = bulk**
  - DPP-pigments
  - SiO_2
- **Others are used as nano and/or bulk material**

(Wigger et al. 2018)

Results – silica product category examples

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Precipitated (68.8%)

- **Elastomers (41%)**
- **Detergents and cosmetics (8.6%)**
- Carrier materials (4.8%)
- Polymers/plastics (4.7%)
- Sealants (3%)
- etc.

Fumed (11.7%)

- **Silicone elastomers (4.9%)**
- Paints/coatings (1.3%)
- Polyester resins (1%)
- etc.

Silica forms
(459'000 metric tons in 30 product uses)

Gel (6.3%)

- **Beer fining (1.8%)**
- Adsorbants
- Paints/coating
- etc.

Colloidal (4%)

- Refractory binders
- Pulp and paper
- Electronics
- Beverage clarification
- Textile processing
- etc.

(Glauser et al. 2014, Wigger et al. 2018)

Approach
probabilistic material flow analysis

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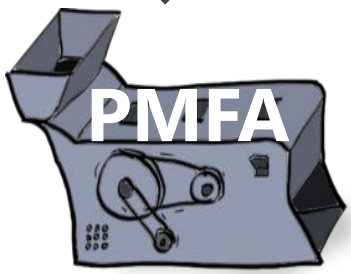
Amount **Products** **Product life cycle**



Transfer coefficients

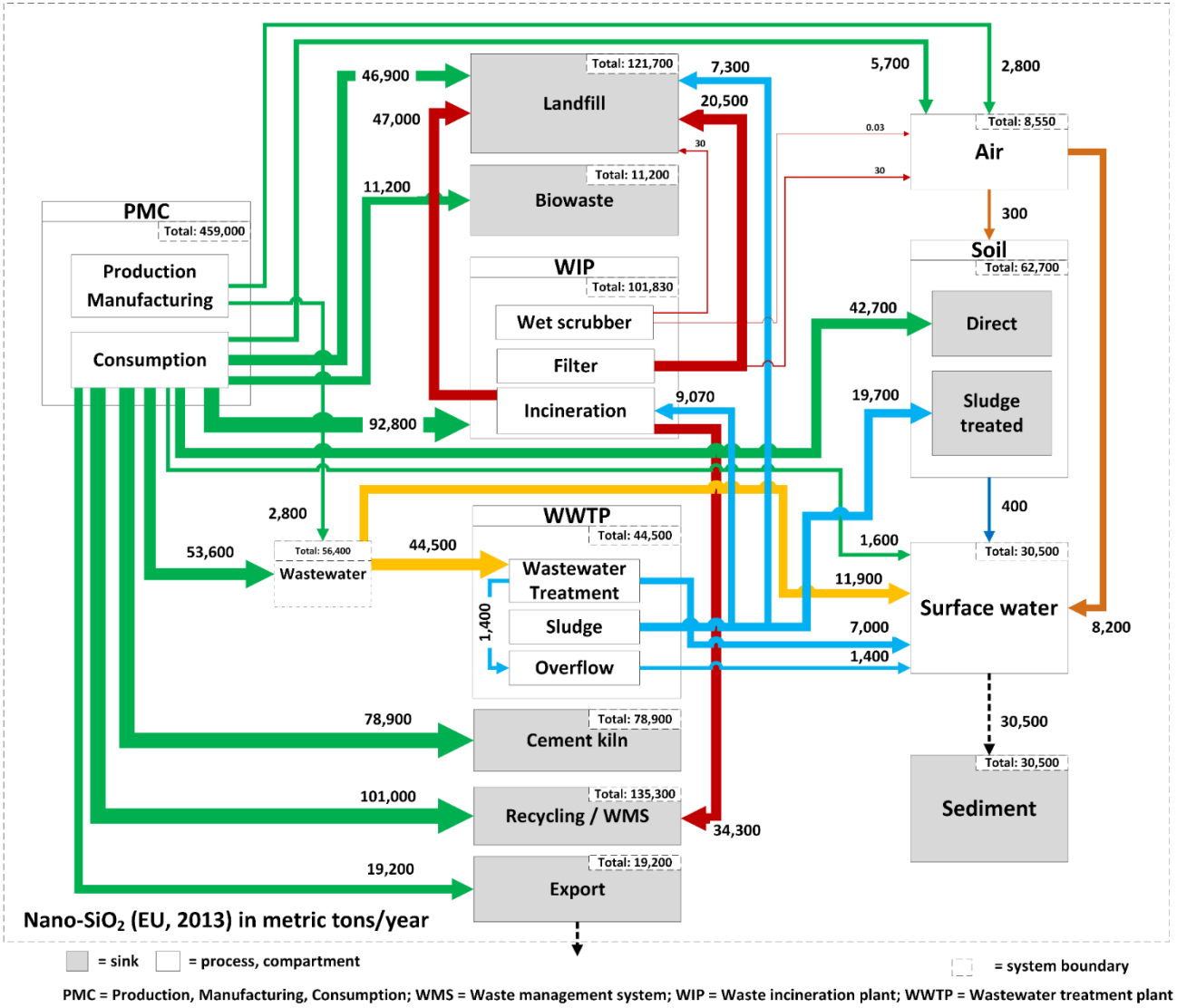
Uncertainties

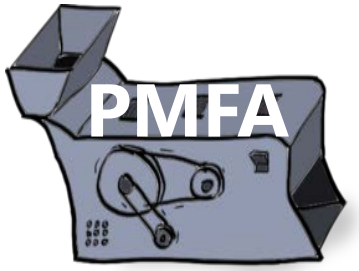
Environmental release

'Standard' environmental compartment (Reach)

PEC

Results: material flow charts for silica in Europe





Main material flows

- Recycling/WMS
- Cement kiln
- WIP
- Waste water
- Soil (direct)

(Wigger et al. 2018)

Results – predicted environmental concentrations of (nano)-silica

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Input parameters	Wigger et al. (2018) Europe	Keller et al. (2013) Europe	Wang and Nowack (2016) Europe	Wang and Nowack (2018) year 2014 Europe
Production volume [metric tons]	459'000	18'050	91'000	599'000
Number of Product categories	30	16	21	21
PEC	**Mean**	**Mean**	**Mean**	**Mean**
Soil (natural+urban) [µg kg^{-1}]	83	**Factor 13**	6.2	86
Sludge treated soil [µg kg^{-1}]	27'000	**Factor 4**	6'300	150'000
Surface water [µg l^{-1}]	8.6	**Factor 4**	1.9	4.3

Conclusions

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- Based on the ENM definition bulk- and nanomaterials became partially distinguishable
  - Some bulk materials became reclassified as ENMs (SiO_2, DPP)
  - Other materials are used as a mix of nano and/or bulk material

- Material flow assessment of silica has shown that
  - data from bulk materials can be used
  - PEC results can vary by a factor of 4 to 13 compared to state of the art studies
  - The application elastomers considerably influences these results

- Future exposure assessments should focus on ENMs with high production volumes and direct environmental release

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Thank you for your attention!

The presentation is based on:

WIGGER, H., WOHLLEBEN, W. & NOWACK, B. 2018. Redefining environmental nanomaterial flows: consequences of the regulatory nanomaterial definition on the results of environmental exposure models. **Environmental Science: Nano, 5, 1372-1385.**

contact: henning.wigger@empa.ch

References

- Glauser, J., Wietlisbach, S. and, Funada C. 2014. Chemical economics handbook - Silcates and silicas, IHS markit, London, United Kingdom
- WIGGER, H., WOHLLEBEN, W. & NOWACK, B. 2018. Redefining environmental nanomaterial flows: consequences of the regulatory nanomaterial definition on the results of environmental exposure models. Environmental Science: Nano, 5, 1372-1385.

- Images on slides 2,3,7 and 8 are taken free of charge from http://worldartsme.com.