Use of modeling to predict environmental concentrations of nanomaterials

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Background

- n ENM are used in numerous applications and products
- n ENM release during production, use and disposal is likely
- n First results about release of ENM published, e.g. from paints and textiles
- n Currently no quantitative trace analytical method available: Therefore no information on environmental exposure available
- n Modeling can provide these data

Material flow to the environment

Product life cycle
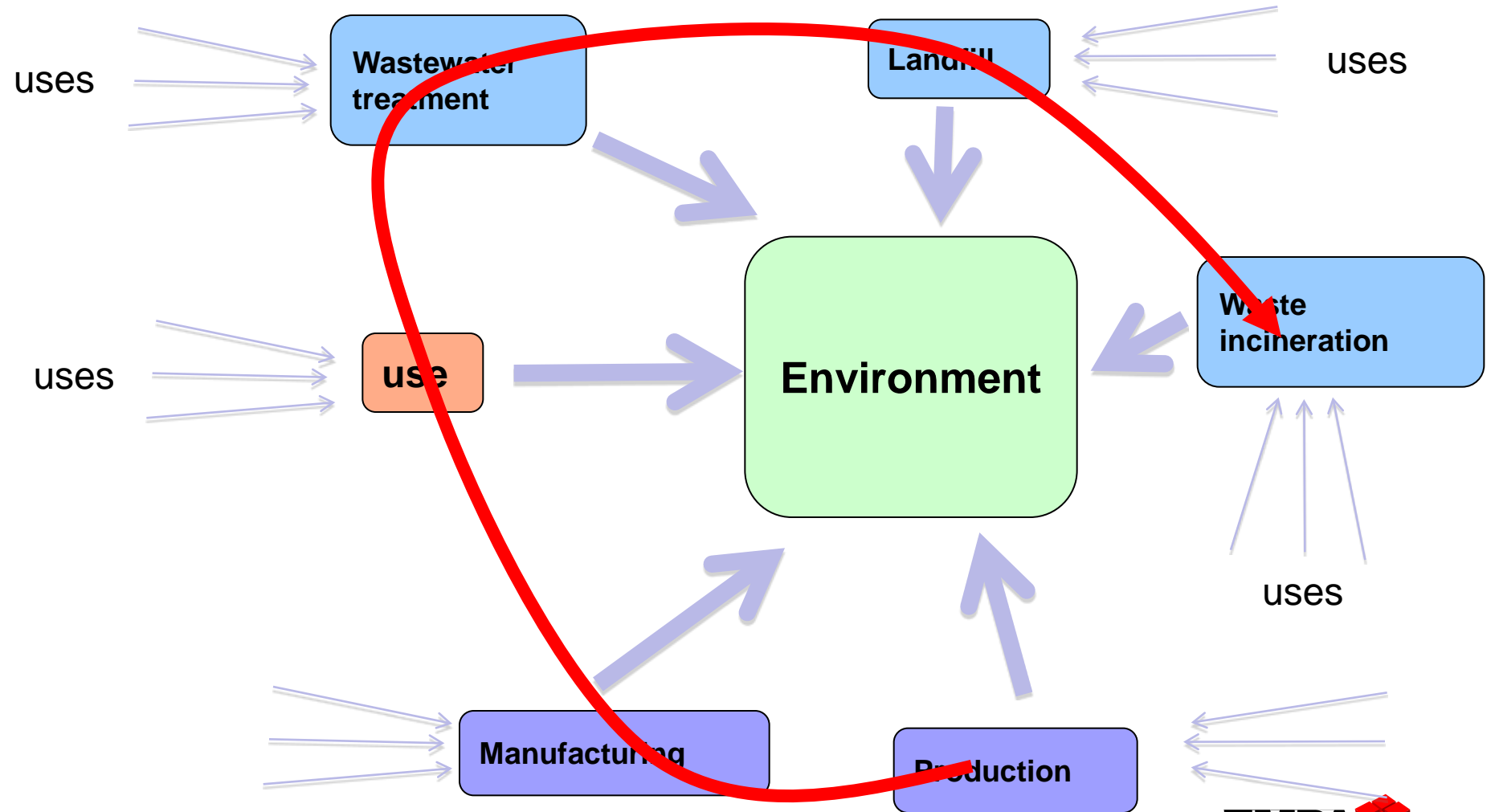
Environmental fate: Multi-compartment modeling
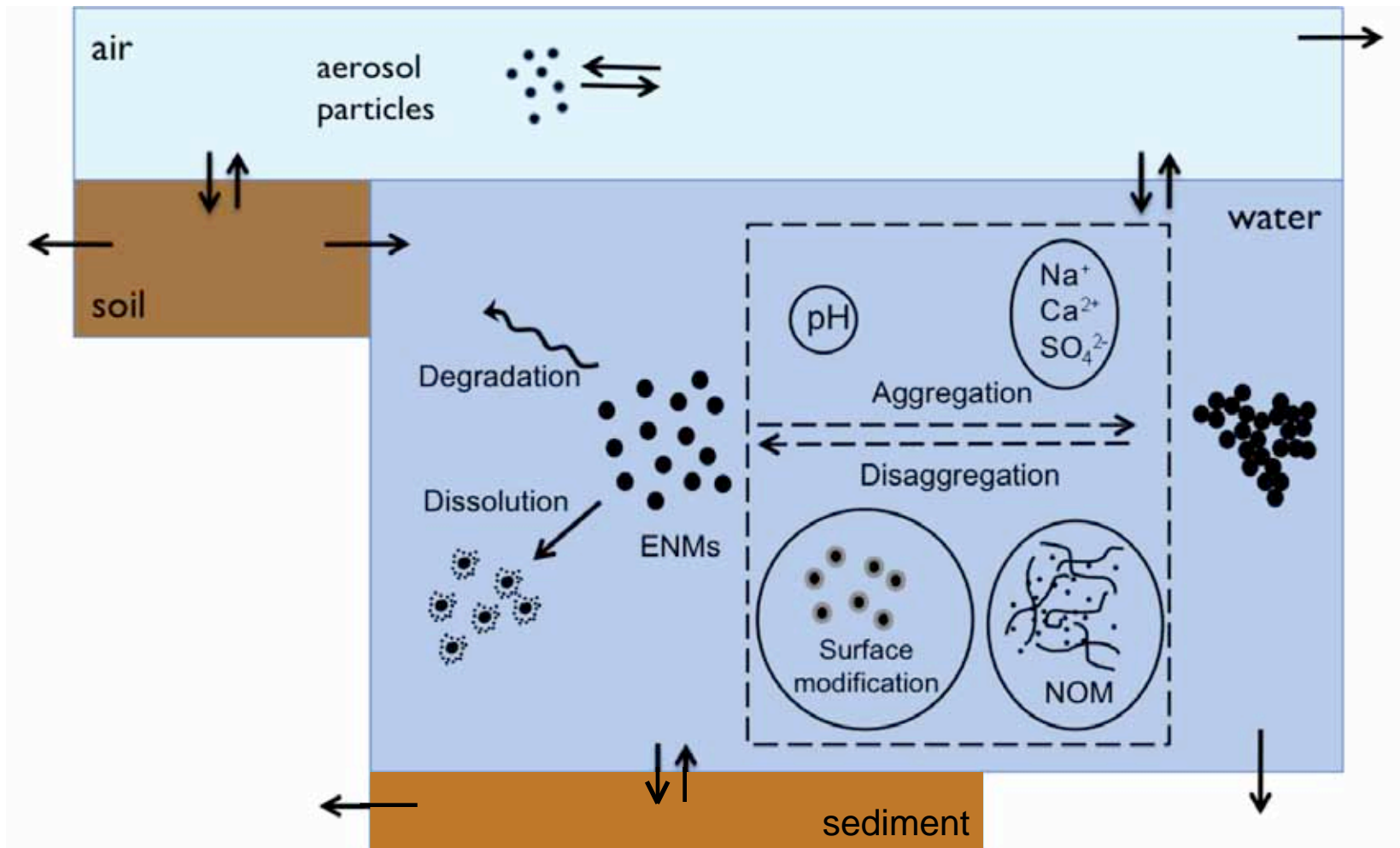
Release of ENM from products

n Some products are used up (e.g. sunscreen): (almost) complete release

n Most products release only part of the ENM

n Only few data available on release

> **n** Paints
>
> **n** Textiles
>
> **n** Coatings

n Estimations required

Material-flow model for nano-TiO$_2$ for the EU (mode values in tons/year)

Gottschalk et al. (2009) *Environ. Sci. Technol.* **43:** 9216-9222.
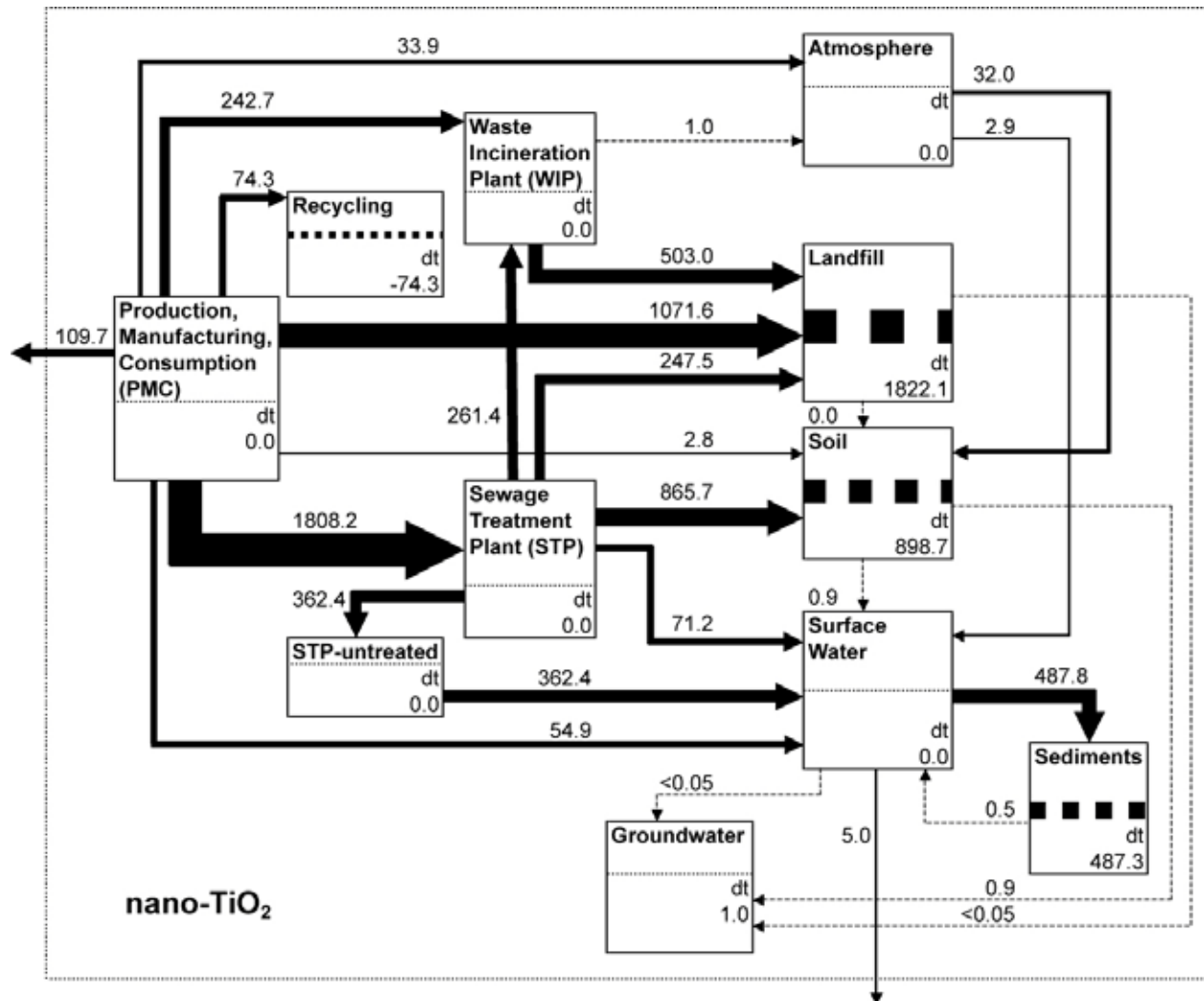
Modeled environmental concentrations in waters of the EU (mode and 15 and 85% quantiles in ng/L)

	TiO$_2$	Ag	ZnO	CNT	fullerenes
Surface water	15 (12-57)	0.8 (0.6-2.2)	10 (8-55)	0.004 (0.004-0.021)	0.02 (0.01-0.12)
Treated wastewater	3'470 (2'500-10'800)	43 (33-111)	432 (136-1'420)	15 (11-32)	5 (4-26)

Gottschalk et al. (2009) *Environ. Sci. Technol.* **43:** 9216-9222.

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Release of Ag from textiles during washing

Geranio, Heuberger, Nowack, *Environ. Sci. Technol.* 43: 8113-8118 (2009)

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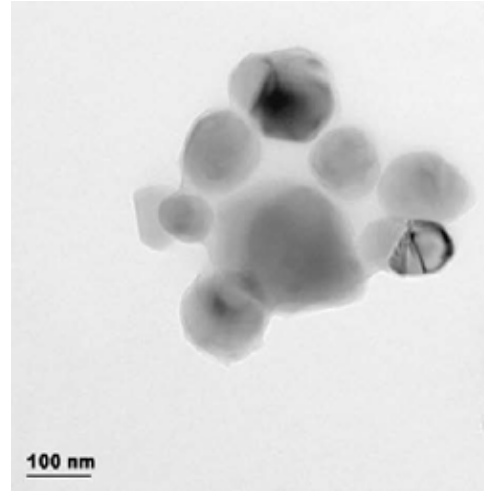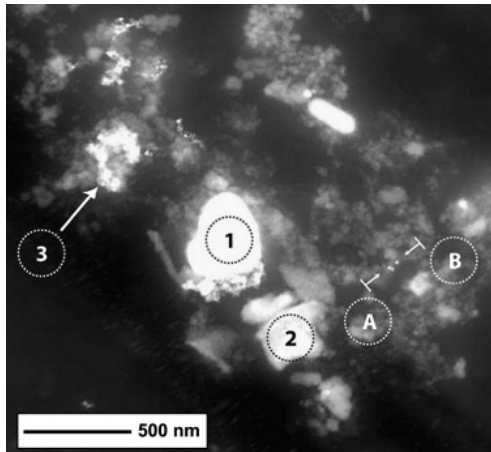Materials Science & Technology
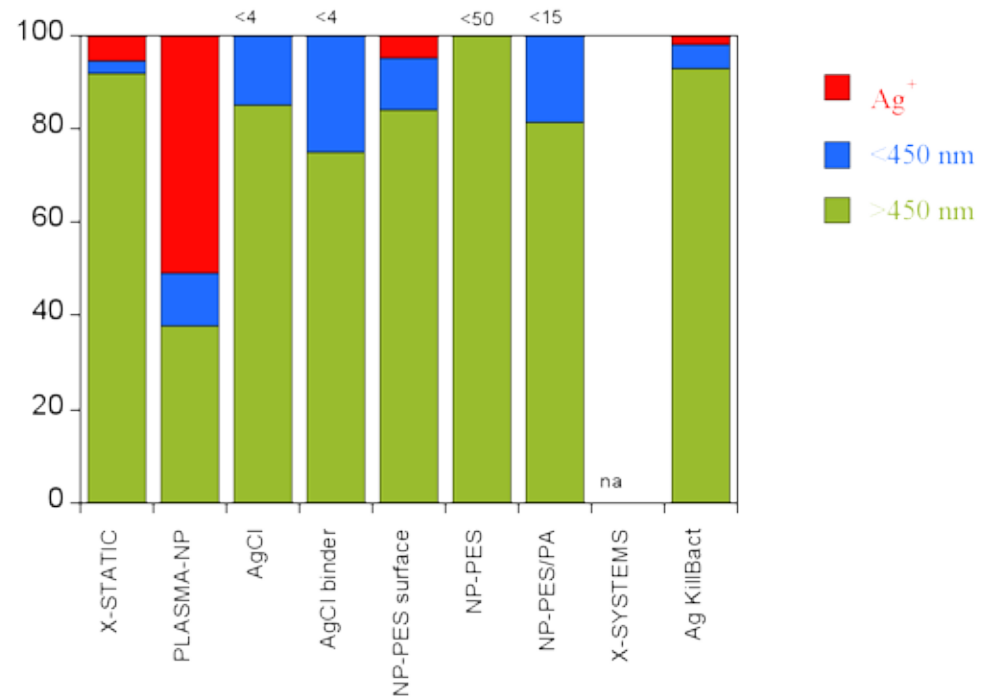
Characterization of released ENM
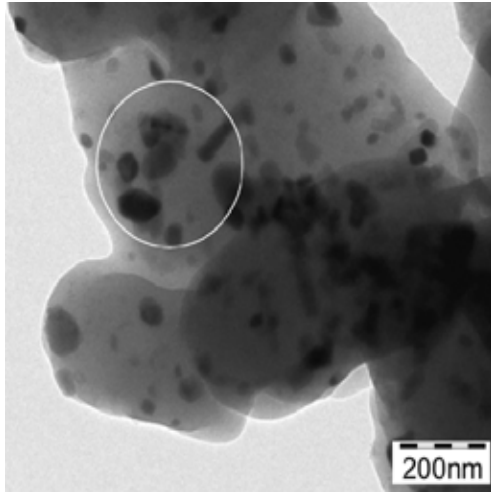
ZnO from a steel panel (Vorbau, 2009)

TiO_2 from paint (Kaegi 2008)

Ag from paint (Kaegi 2010)

Ag from a medical mask (Benn 2010)

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Open issues in current models

n All modifications of one ENM are lumped together (e.g. coated-uncoated, different mineralogical forms)

n Form of released materials is not considered

    n Free particles?

    n Matrix-bound?

    n Nanoparticulate?

In what form are ENM present in the environment? Silver as example
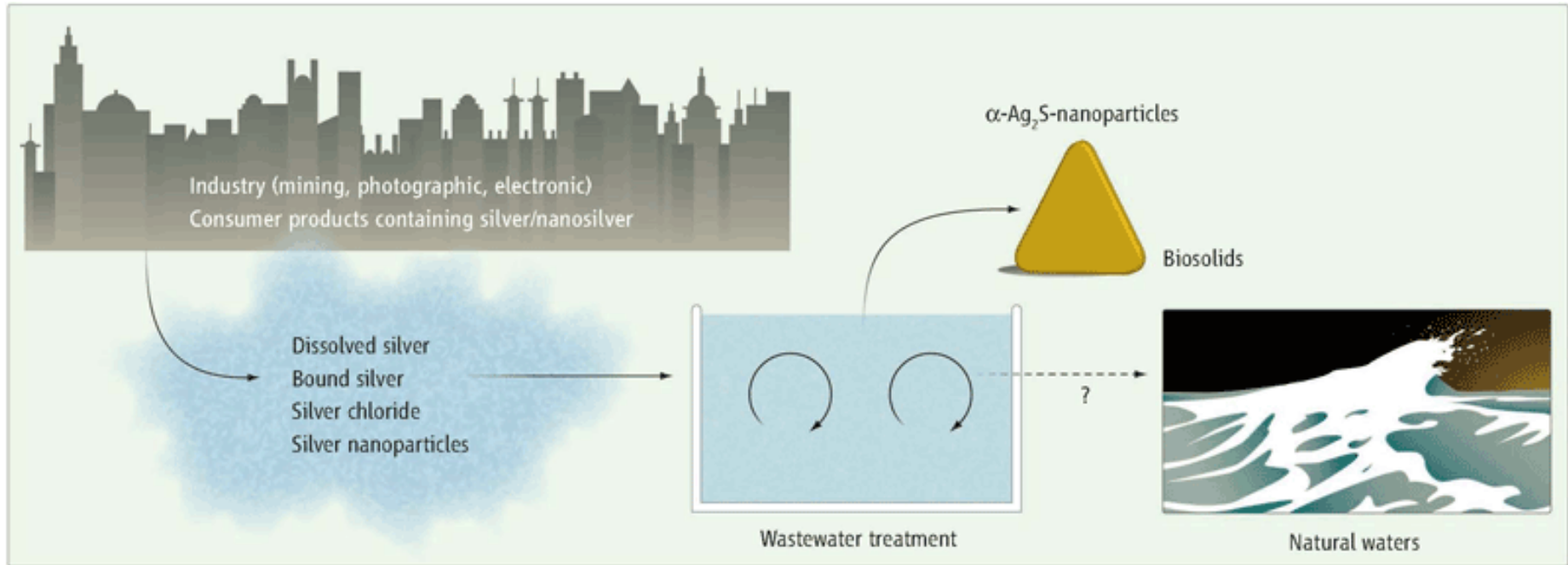
Nowack, *Science* 330: 1054-1055 (2010)

Conclusions

- **n** All release paths need to be covered to estimate environmental concentrations

- **n** Very few data on environmental release from products available

- **n** Very little information on form of released ENM available

- **n** Bulk form and dissolved metals need to be considered, too

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