HAZARD ASSESSMENT OF NANOMATERIALS WITH RESPECT TO THE ENVIRONMENT – OVERVIEW AND SELECTED ASPECTS

Fraunhofer IME

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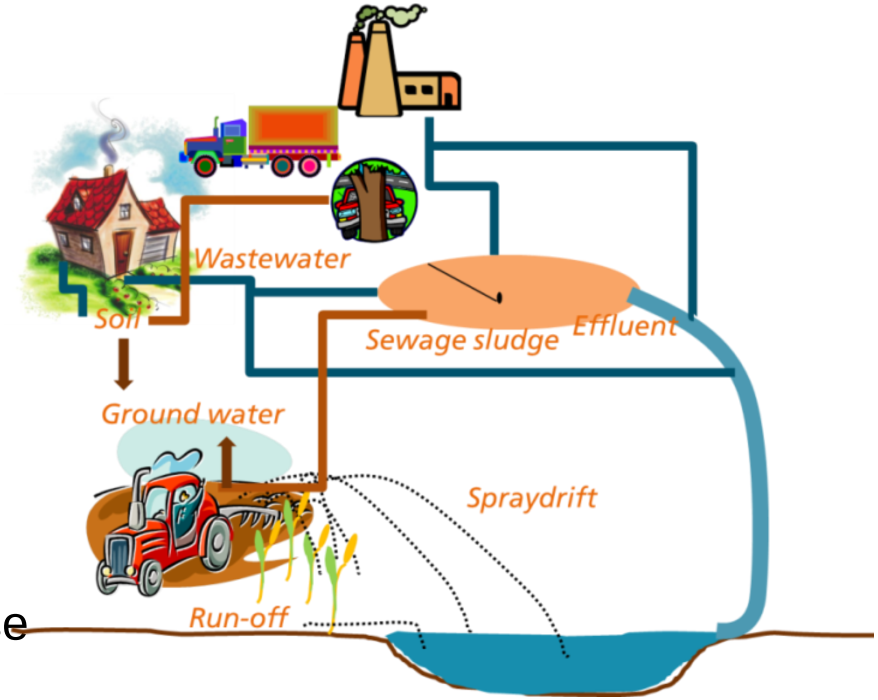
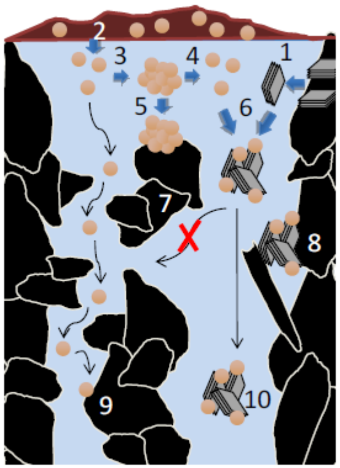
OUTLINE

- Introduction
- Overview on testing
- Selected aspects
  - Test concentrations
  - Illumination
  - Transformation (aging)

Introduction

- Regulation in Europe
  - Regulation under REACH
  - Specific area of application (specific legislation)
- Topics under discussion
  - NM to be tested
    - Assessment of NM in any case
    - Exposure driven assessment
      - Life-cycle of NM
      - Release into the environment
      - Durability (loss of NM propertie
      - Environment
        - Primary compartment
        - Secondary compartment





Cornelis et al., 2014

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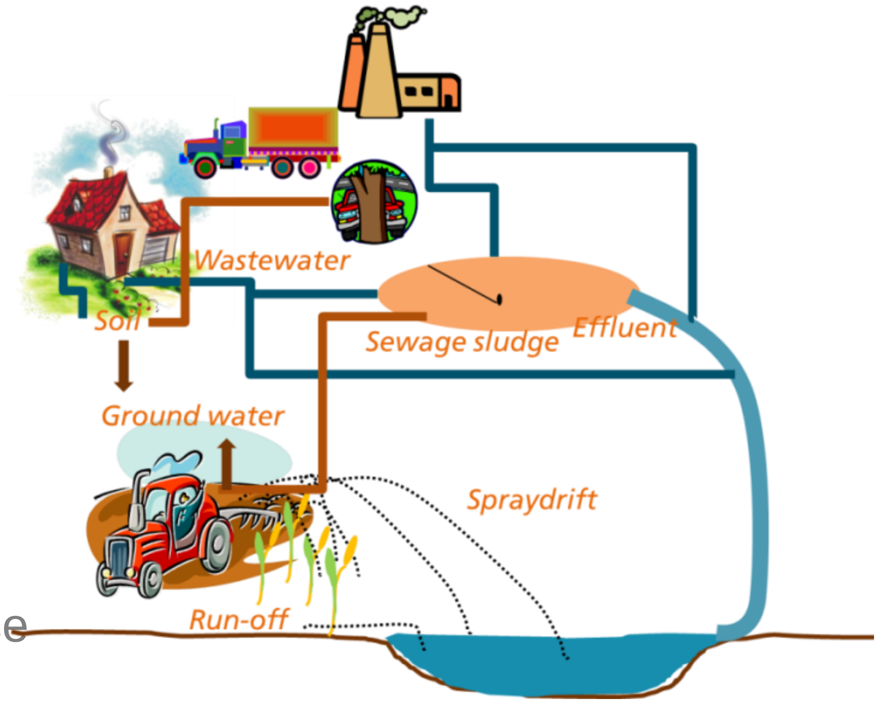
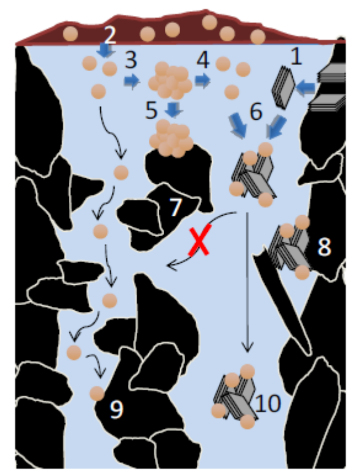
Introduction

- Regulation in Europe
  - Regulation under REACH
  - Specific area of application (specific legislation)
- Topics under discussion
  - NM to be tested
    - Assessment of NM in any case
    - Exposure driven assessment
  - Test strategy
    - Discussion on test methods
    - Discussion on PC-properties suitable as trigger for environmental testing





Cornelis et al., 2014

Assessment of nanomaterials

Fate

- Modelling
- Testing (new or adapted TG: sorption, accumulation, agglomeration, dispersion, dissolution)

→ n-PECini; n-PECsec

Effects

- Testing

→ ECx, NOEC → PNEC

Predicted environmental risk quotient:

n-PEC / nPNEC

Classification / Labelling

> 1

↓

Refinement:
more sophisticated tests

Test strategy: Tier 1 - Effects

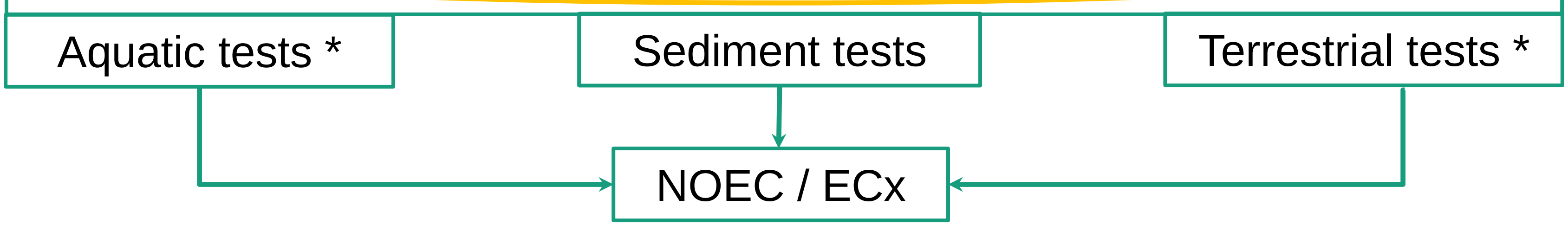
Testing:

Current scope of testing for chemicals: production volume

single species tests: acute aquatic tests → chronic aquatic tests → terrestrial tests

Nanomaterials: exposure differs (sedimentation, agglomeration) → most sensitive compartment still unknown

Proposal: Scope of testing for NM independent of production volume



** Including uptake*

Assessment of Hazard

- OECD WPMN (Working Party on Manufactured Nanomaterials)
  - Screening of OECD TGs on ecotoxicty
    → principally suitable
    - Main topics under discussion
      - Application of NM (soil, sediment: dry or wet?)
      - Stability of test dispersion during testing (water: preferably no dispersant / stabilizer / DOM)

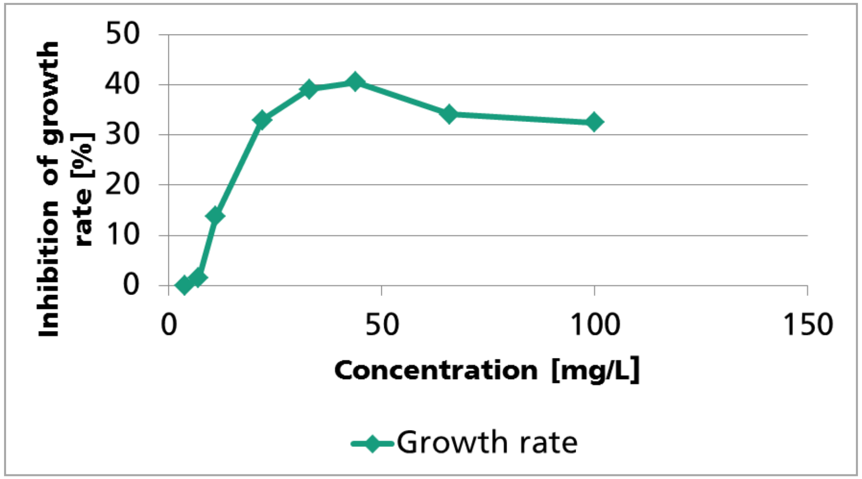
Topic: Test concentrations

- Conventional chemicals
  - Screening: Limit tests
- Nanomaterials
  - Plateau (maximum effect below 100 %) or lower effects in higher test concentrations
    → Several test concentrations

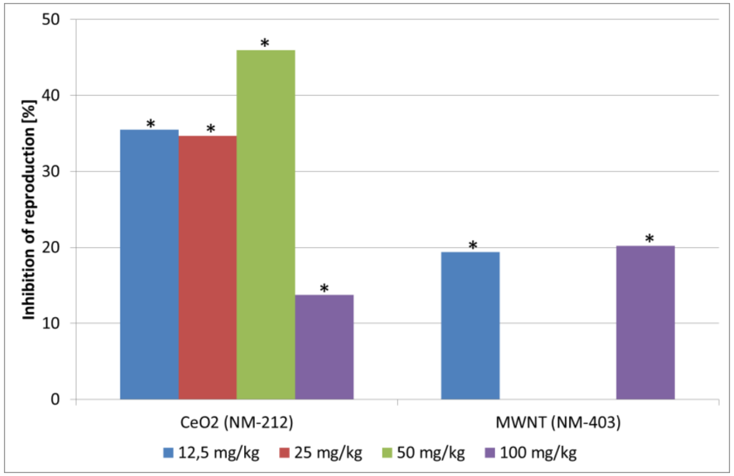
- Recommendation – Testing of NM

  No limit test!

TiO_2: growth test with algae



CeO_2, MWCNT: reproduction test with earthworms



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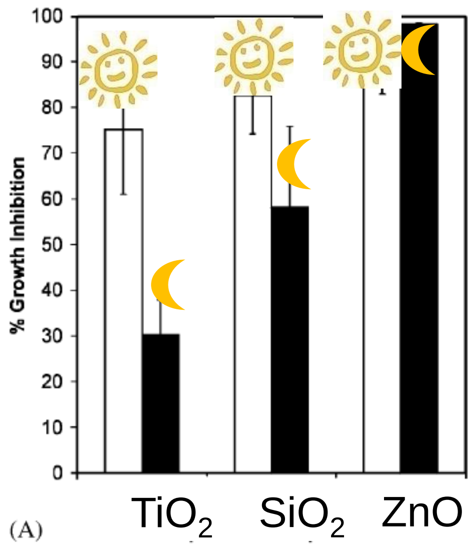
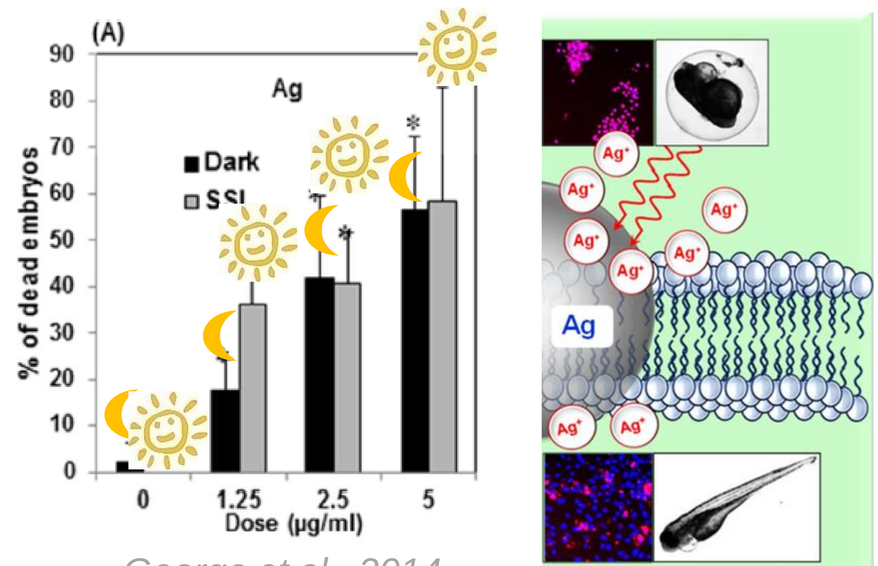
Topic: Illumination

- NM designed for photocatalytic activity (e.g. TiO_2)
  → increased aquatic toxicity if relevant wavelengths are applied
  no consideration in test guidelines
- Not limited to photocatalytic NM



Adams et al., 2006

Effect of illumination on growth of B. subtilis (■ dark)



George et al., 2014

Effect of illumination on fish embryo survival (■ dark)

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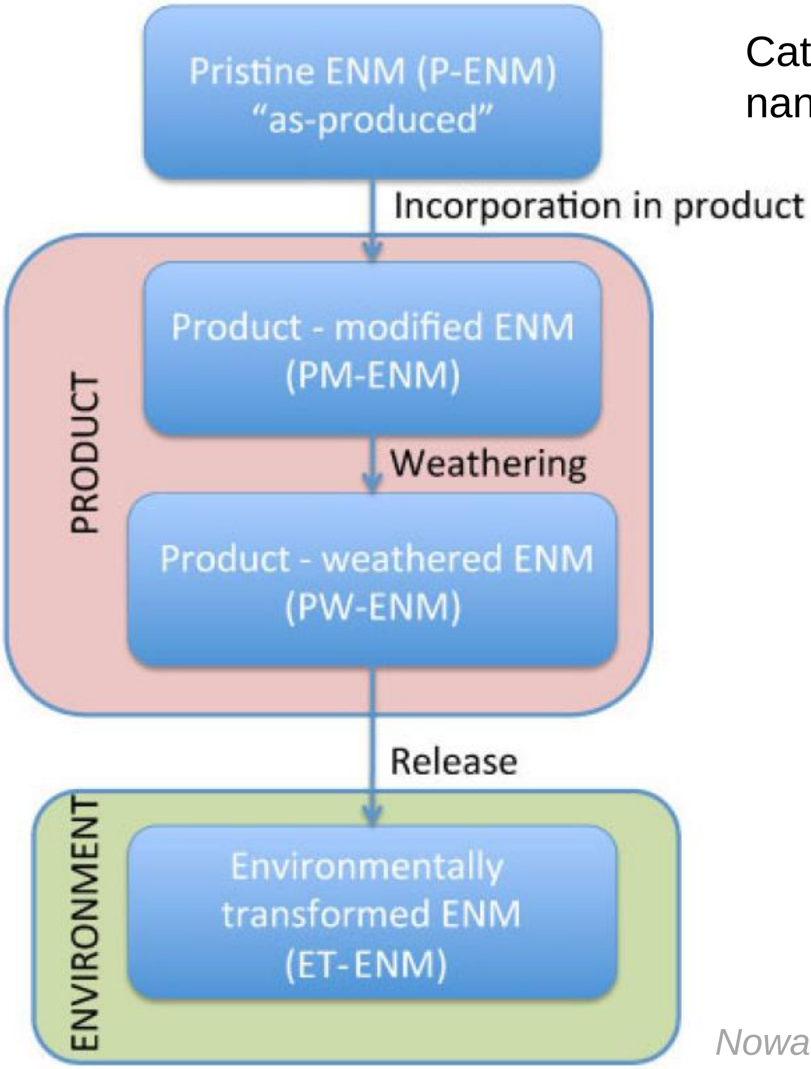
Topic: Illumination

- Recommendation
  - Testing applying conventional illumination and lighting with simulated sunlight.

    → Results of test conditions with highest ecotoxicity used for hazard assessment.

Topic: Transformation

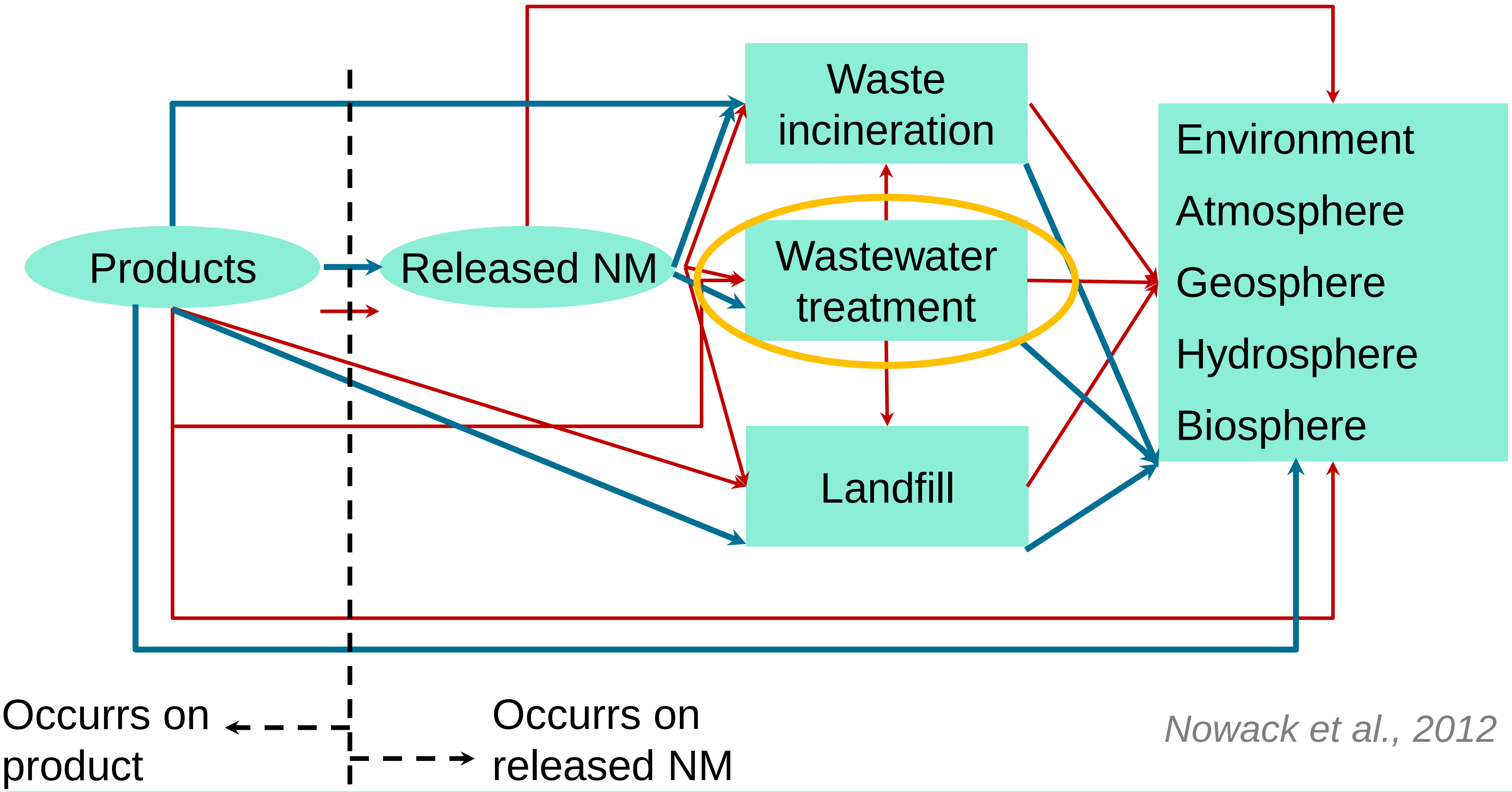


Categorization of engineered nanomaterials

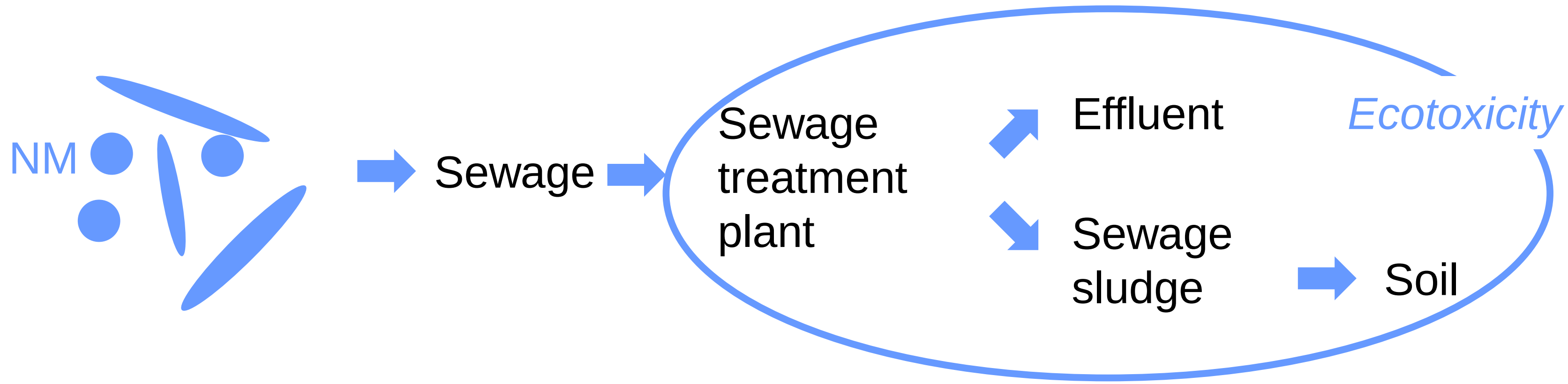
Nowack et al., 2012

Material flow diagram: products → environmental compartments

- Nano-Ag in socks
- Nano-TiO_2 in sunscreen



Nowack et al., 2012



nano-TiO_2 - Europe:

STP effluent: 0.00347 mg/L

STP sludge: 136 mg/kg

nano-Ag - Europe:

STP effluent: 0.0000425 ng/L

STP sludge: 1.68 mg/kg

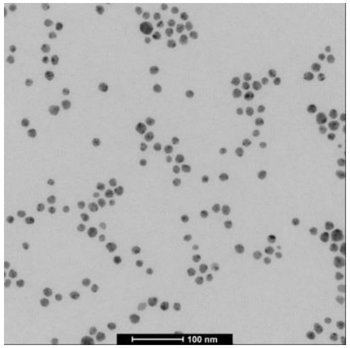
Gottschalk et al., 2009

Methods: simulation of sewage treatment plants

- Model sewage treatment plants
  - OECD 303a
    (device designed to determine the elimination and biodegradation of water-soluble organic compounds by aerobic micro-organisms)
  - Denitrification tank, aeration tank (2 – 3 mg O_2/L), sedimentation tank
  - Sewage sludge: local wastewater treatment plant
  - Continuous influent (synthetic sewage) and effluent
  - Retention time comparable to industrial-scale plant (6 h); mean sludge time: 10 d
- Process control
  - DOC, NH_4^+, NO_2^-, NO_3^-

Methods: Nanomaterial

- Nano silver (OECD Sponsorship Programme)

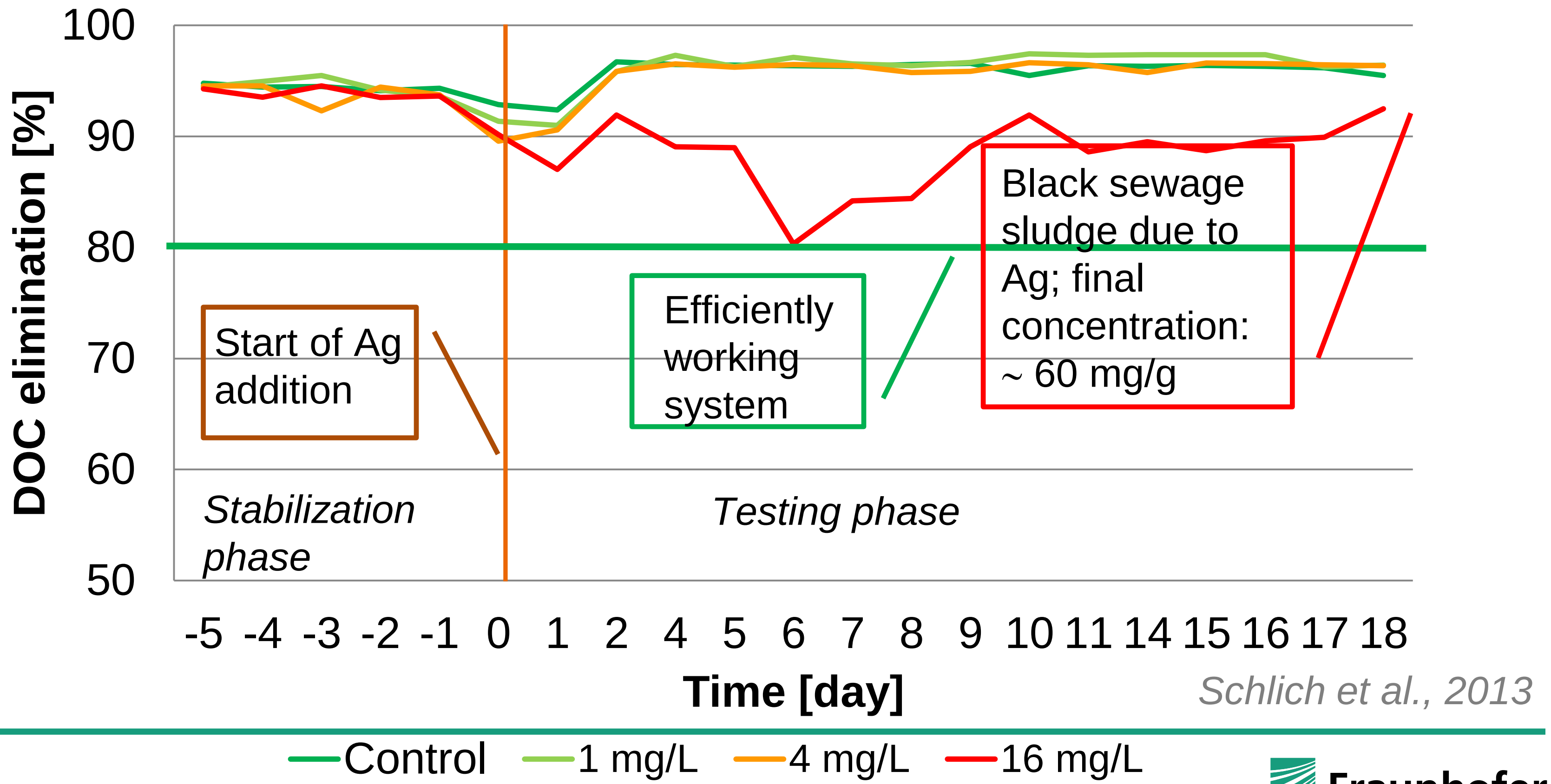


TEM: Coda Cerva, Brussels

  - NM-300K
    - Spherical: Ø ~15 nm

I. Fate/effect of Ag in sewage treatment plant

- Continuous influent of nano-Ag: 0.04 – 16 mg/L
- Sorption to sewage sludge; 0.04 – 4 mg/L: ~ 90 %
  16 mg/L: 39 – 64 %
- NM-300K : no inhibition of C-degradation



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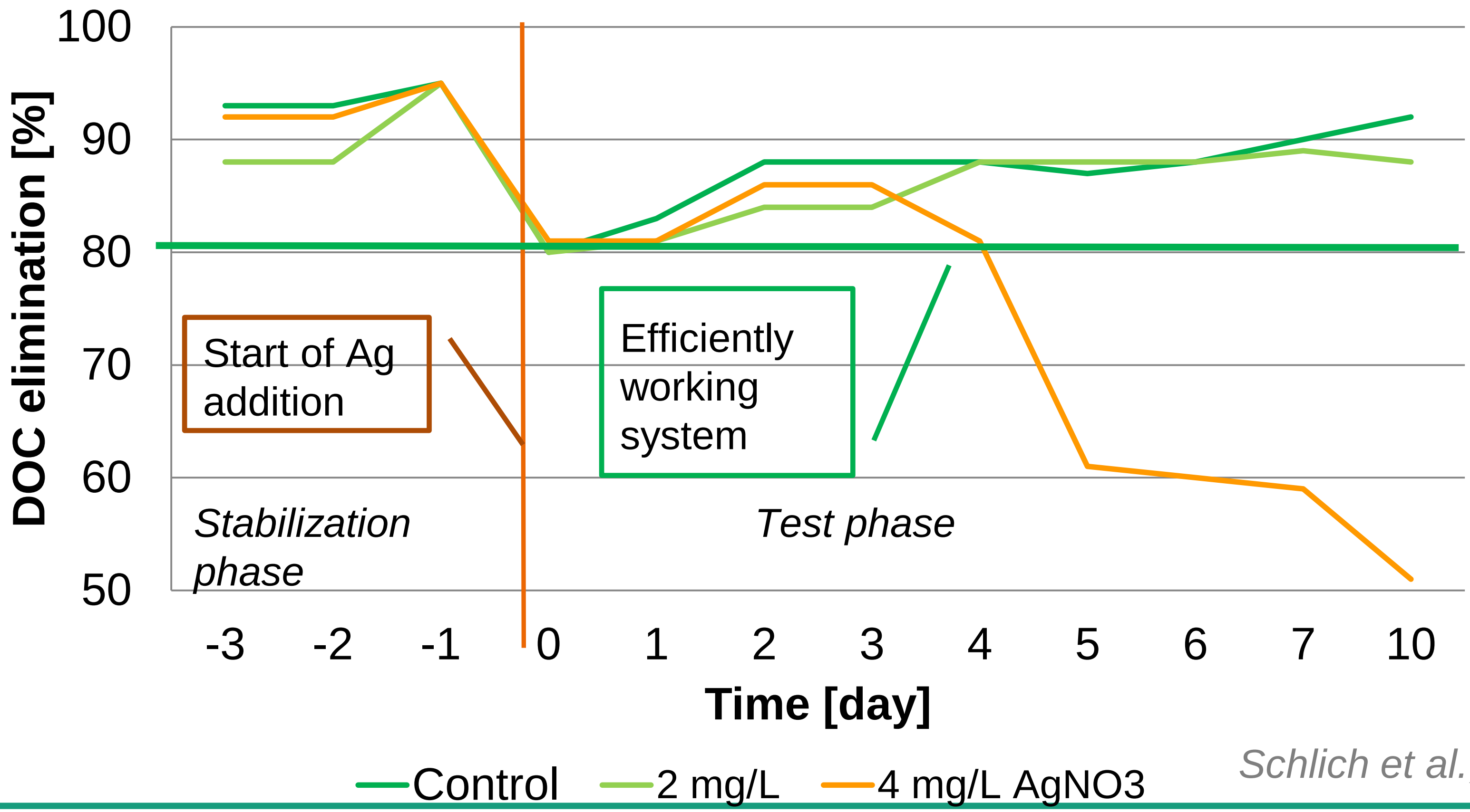
I. Fate/effect of Ag in sewage treatment plants

- Ag ($AgNO_3$): > 90 % sorption to sewage sludge (0.4 – 2 mg/L)
- Ag ($AgNO_3$): 4 mg/L: 57 – 99 %
- Inhibition of C-degradation by $AgNO_3$ (4 mg/L)



Schlich et al., 2013

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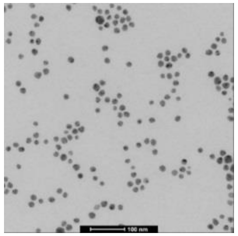
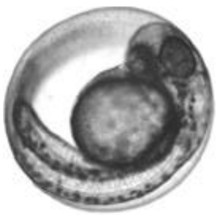
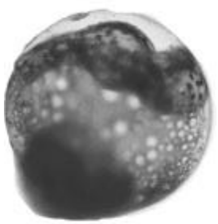
II. Effluent – NM-300K: Development of fish embryos (OECD 236)



	EC50 (48 hpf)
Pristine NM in mineral medium	1.09 mg/L
Pristine NM + control effluent	2.08 mg/L
Effluent	0.14 mg/L

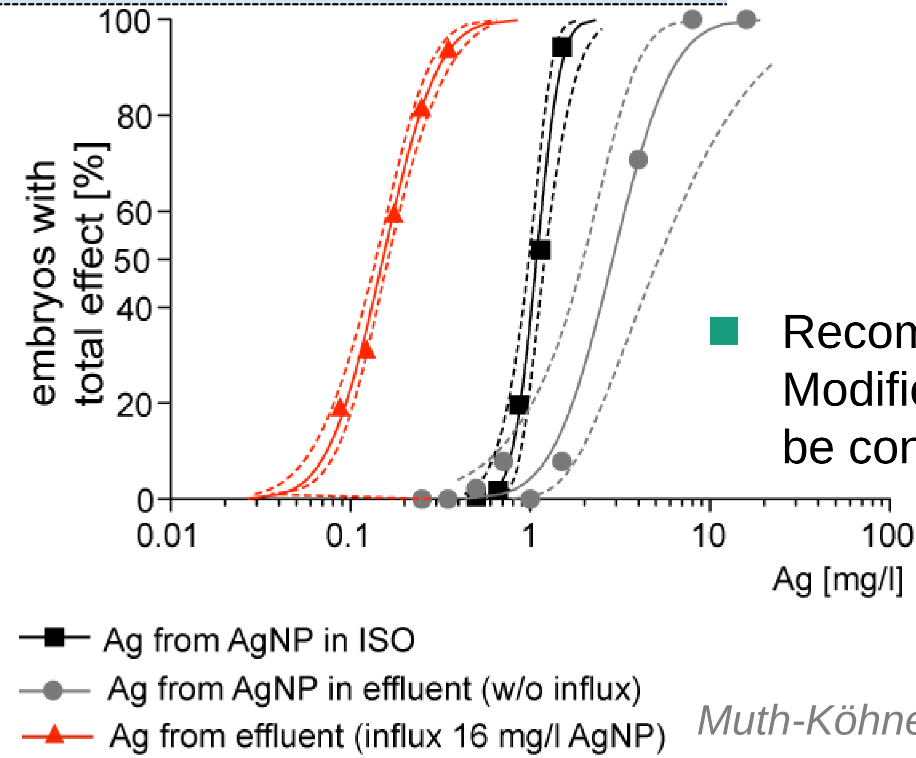


Control



0.87 mg/L

1.5 mg/L

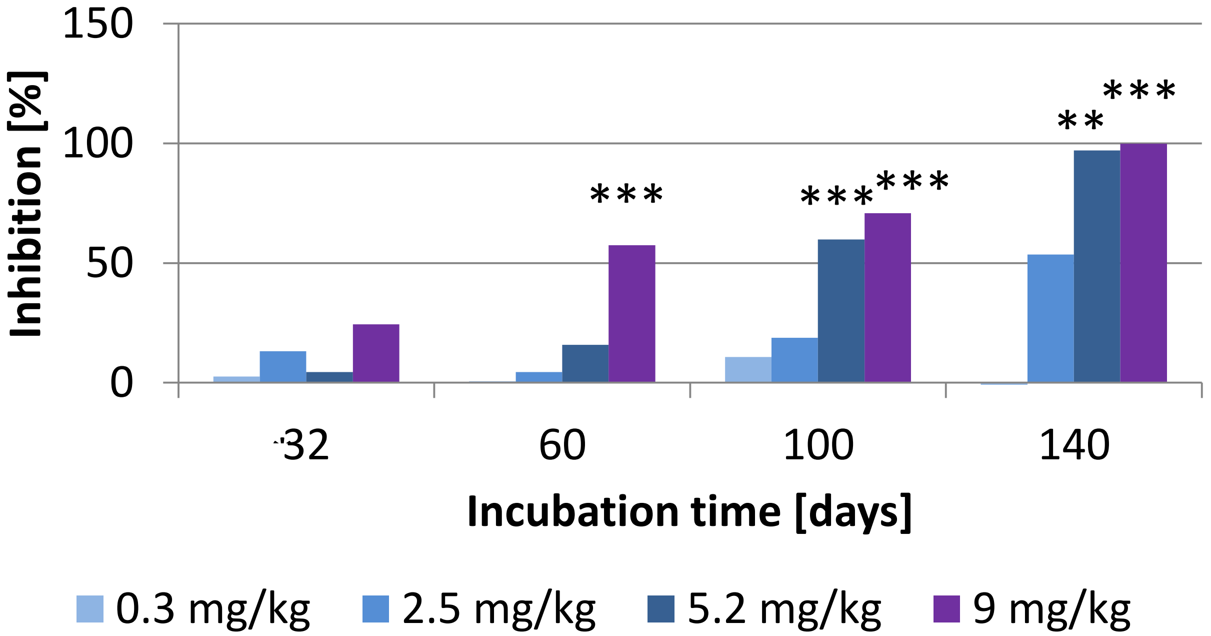


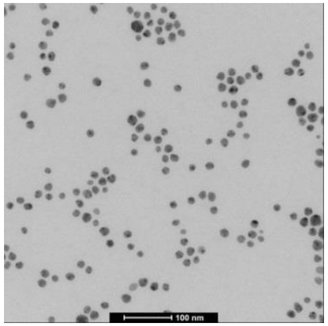
- Recommendation Modification has to be considered!

Muth-Köhne et al., 2013

III. Soil + sewage sludge – NM-300K: Potential ammonium oxidation (ISO 15685)

	EC50
Pristine NM in soil: 28 d	1.6 mg/kg
Sewage sludge with Ag + soil: 30 d	No effect
Sewage sludge with Ag + soil: 140 d	2.3 mg/kg





- Bioavailability of NM increases

Schlich et al., 2013

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Recommendation: Hazard assessment of NM

- Consideration of the three environmental compartments (water, sediment, soil) unless exposure / ecotoxicity can definitely be excluded.
- No limit test, testing of several test concentrations.
- Illumination has to be considered.
- Modification / bioavailability of NM over time has to be considered (aging of NM).