



*Scaling up laboratory-to-mesocosm  
studies: Applications beyond  
engineered nanomaterials*



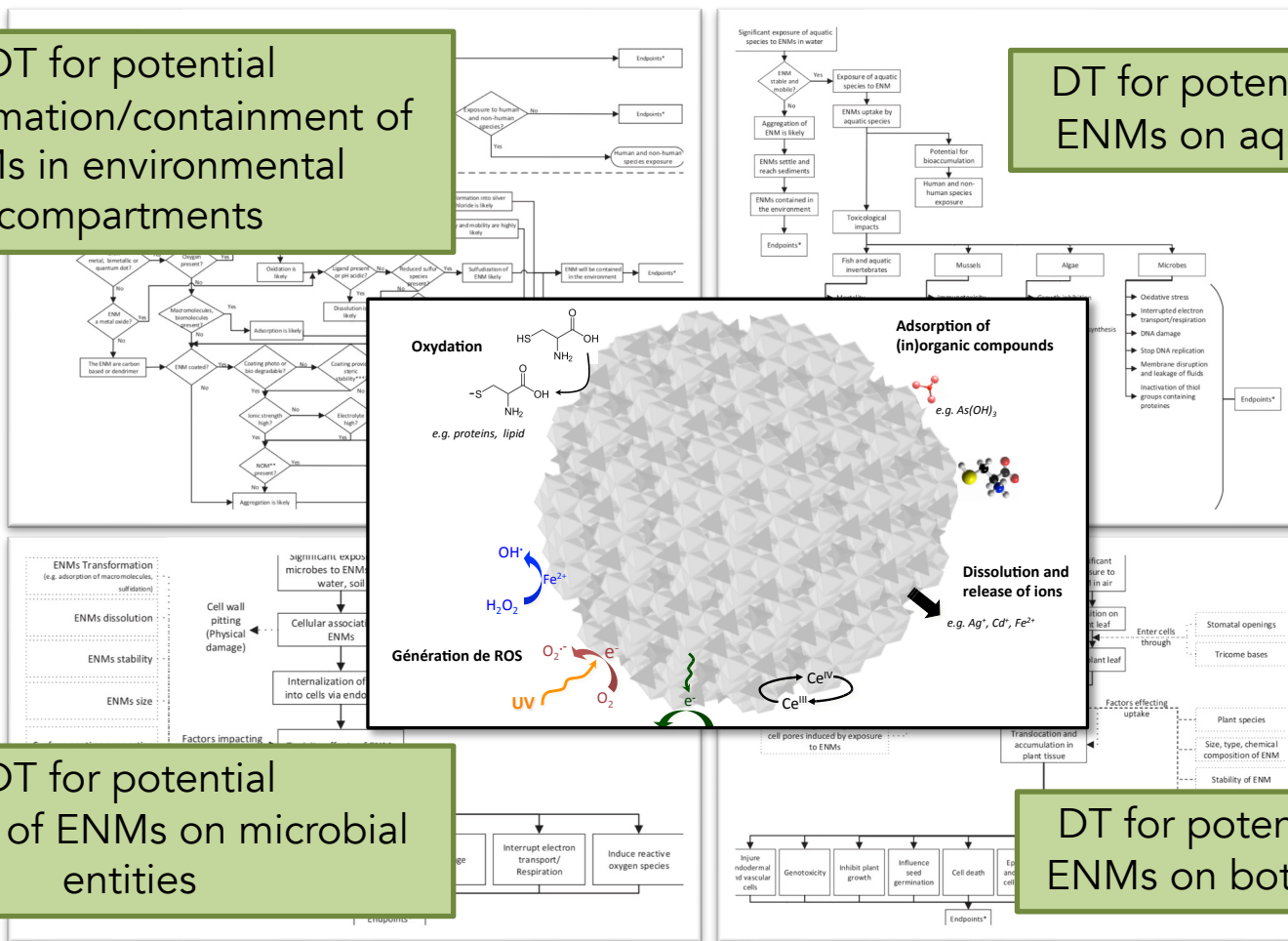


# Environmental risk assessment of ENMs

## Multiple decision tree (DT)-based approach...

DT for potential transformation/containment of ENMs in environmental compartments

DT for potential effects of ENMs on aquatic species



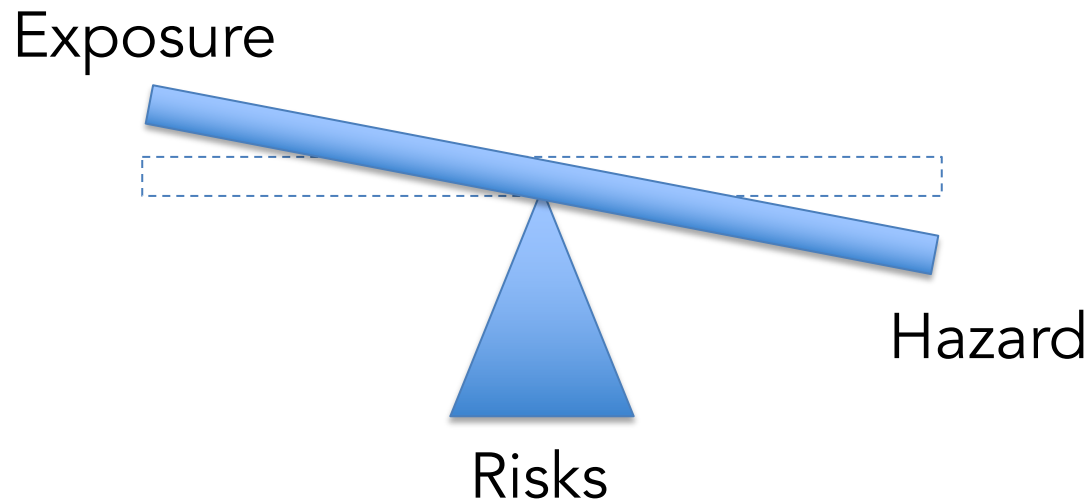
DT for potential impacts of ENMs on microbial entities

DT for potential effects of ENMs on botanical entities



# Environmental risk assessment of ENMs

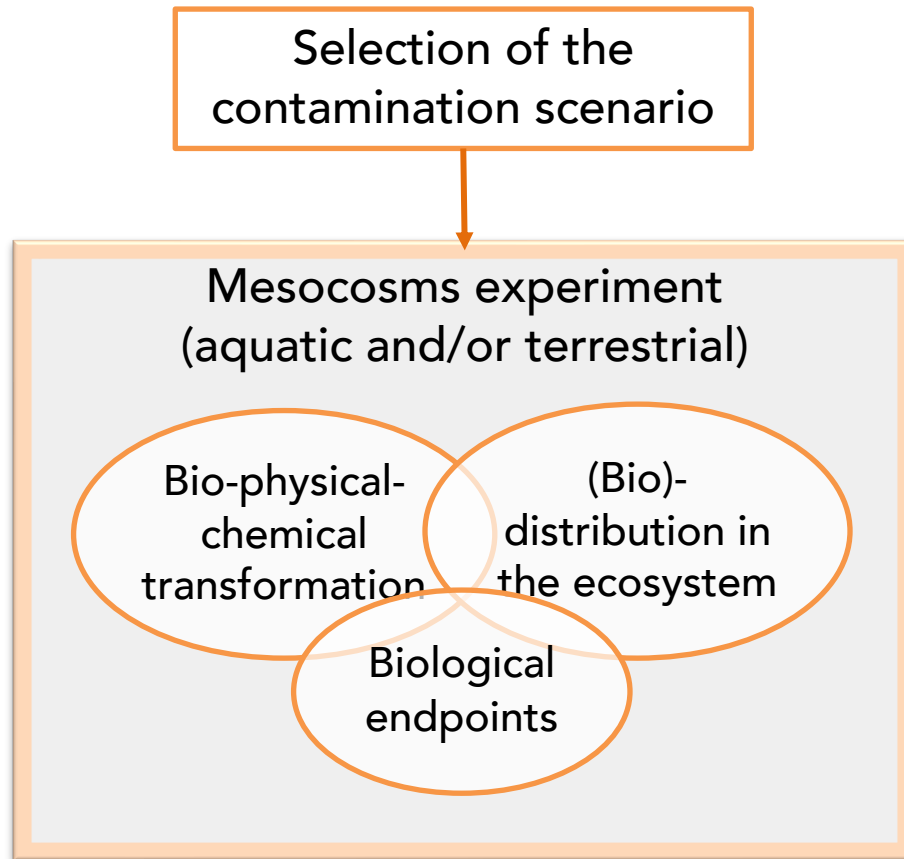
$$\text{Risk} = \text{Exposure} \times \text{Hazard}$$





# Environmental risk assessment of ENMs

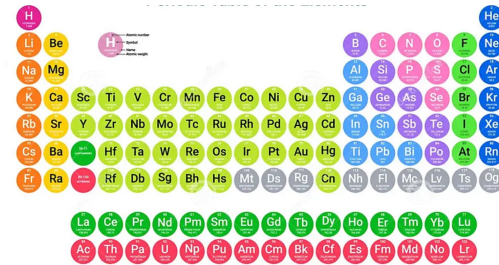
... versus a *Single decision-based approach*





# Selection of relevant exposure scenarii

## Contaminants



*Environmental aquatic/terrestrial ecosystems (Pond, river, estuary, seawater, soils...)*



*One shot vs. multiple/chronic contaminations*

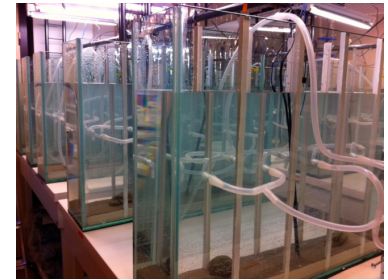
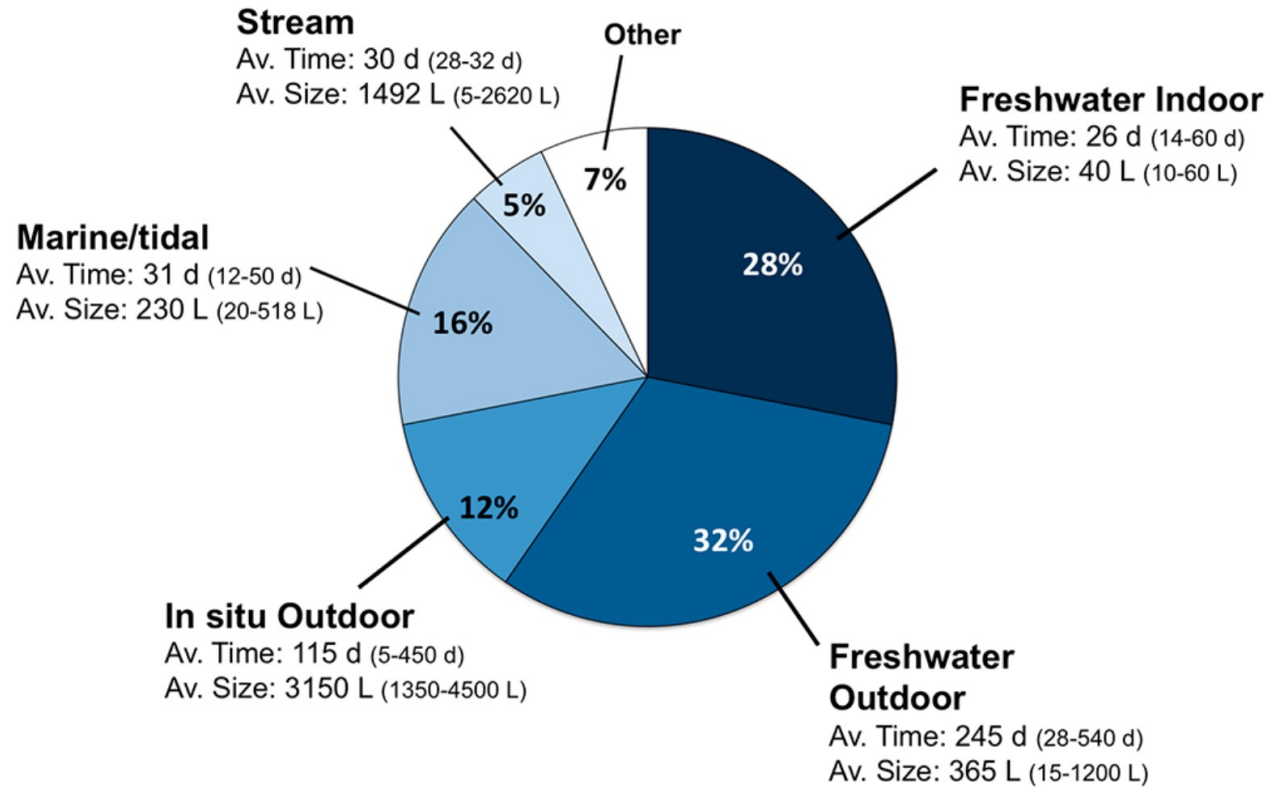
*Mid-term / Long-term exposure*

*Dose (Predicted environmental concentrations)*





# Mesocosm designs used for ERA of ENMs



EU SOP, 2017





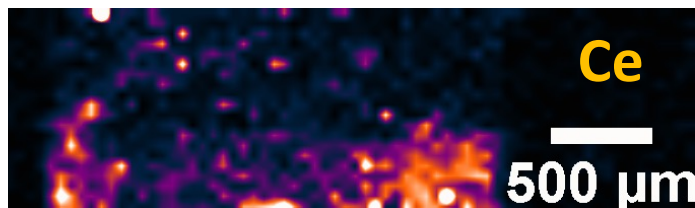
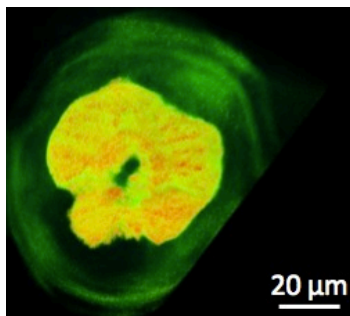
# Detection et characterization in complex media?

Can we detect them ?

[ENMs]<sub>PEC</sub> : ng/L, ug/L to mg/L

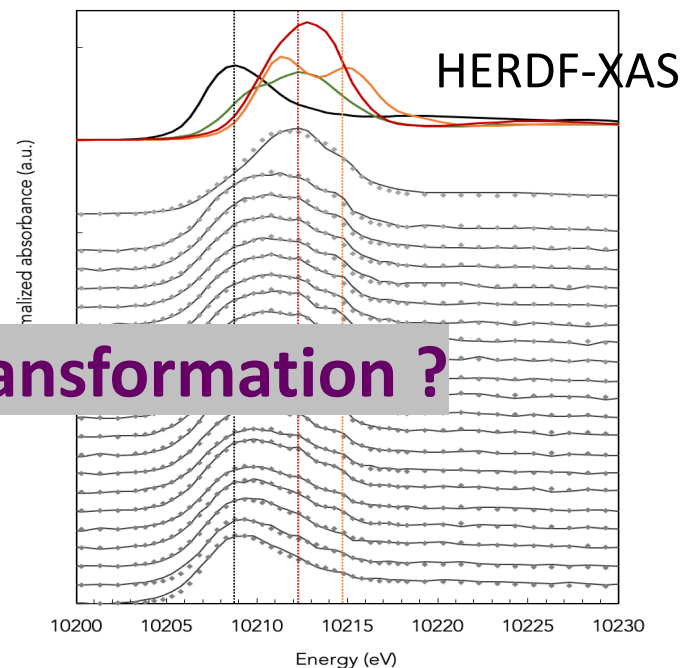
(bio)distribution ?

X-ray nano-  
tomography

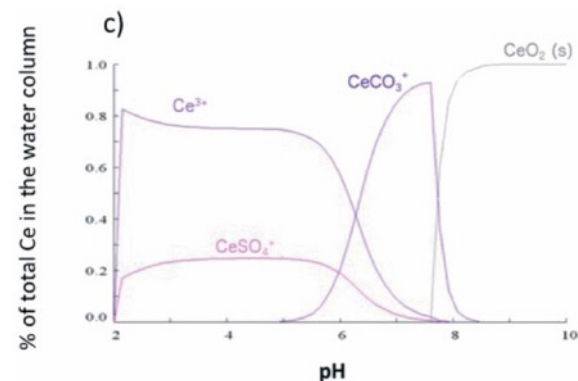


2D chemical  
mapping

(bio)transformation ?

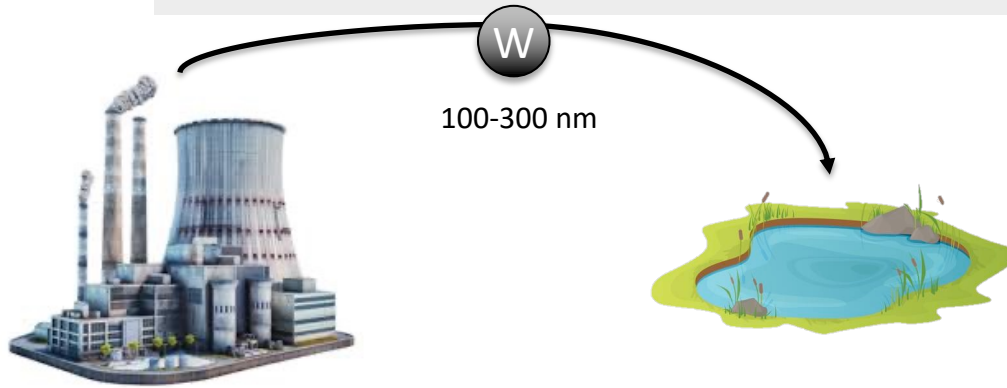


Modeling





# Ex : release of nanoW during tokamak operation and maintenance



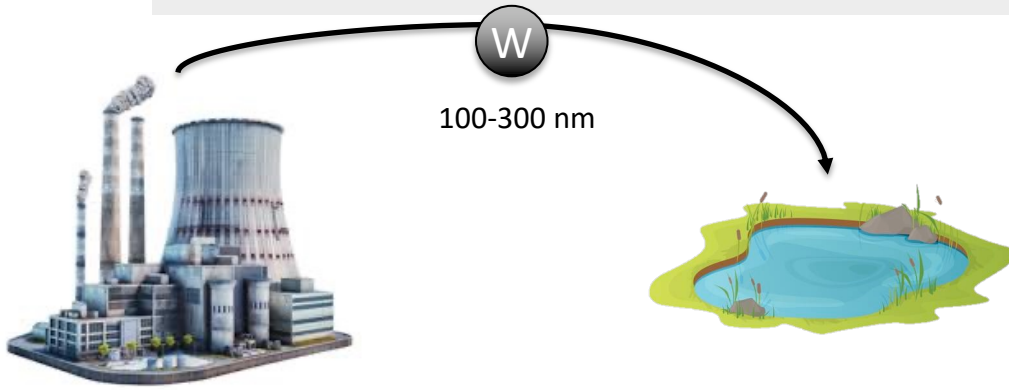
- 1.5 month
- 0.75 mg/L W(0)
- Pond



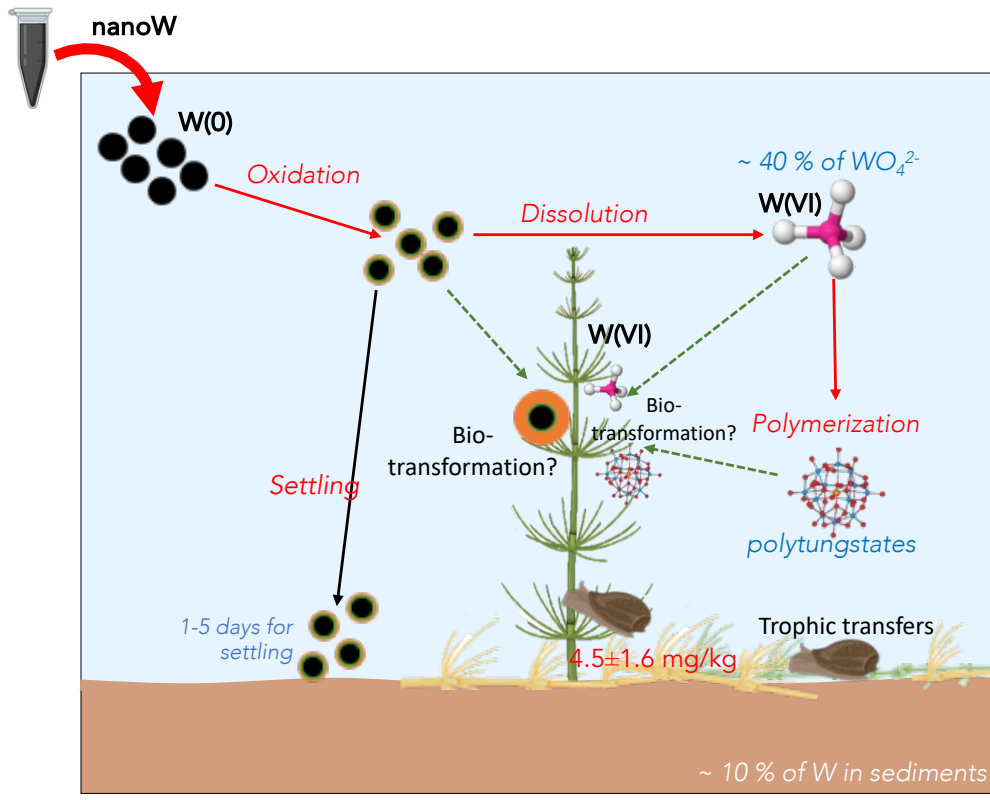




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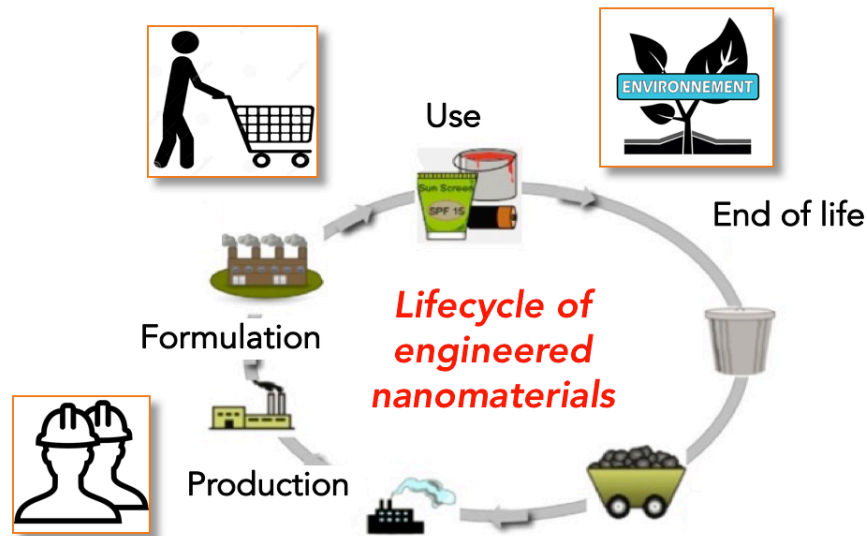
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Ouaksel et al.  
(in revision)



>15 years of exposure and hazard data obtained in mesocosms exposed to ENMs

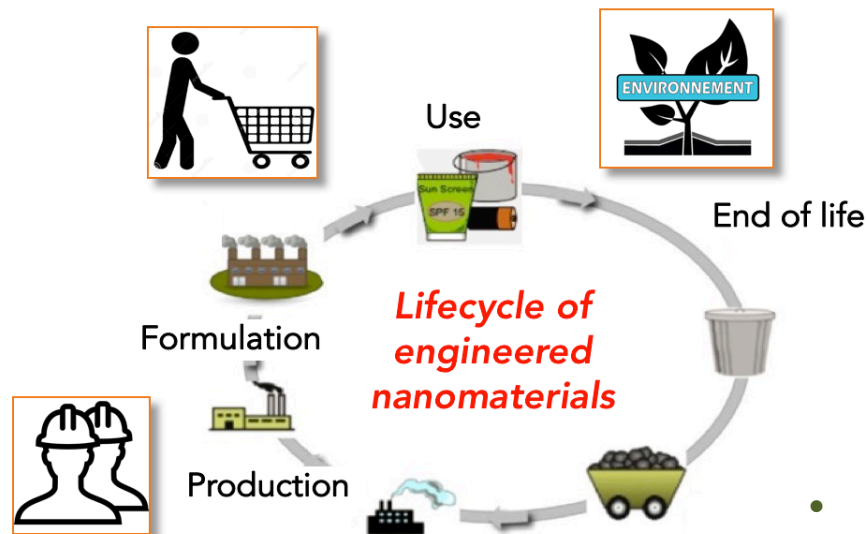


Pristine nanoparticles

- nanoCeO<sub>2</sub>
- nanoAg
- nanoTiO<sub>2</sub>
- nanoCuO
- nanoW
- CNT
- ... with tuned surface and bulk properties



# >15 years of exposure and hazard data obtained in mesocosms exposed to ENMs



Pristine nanoparticles

- nanoCeO<sub>2</sub>
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- ... with tuned surface and bulk properties

Nano-enabled products

- nanoAg-based textiles
- nanoCeO<sub>2</sub>-based diesel additives
- nanoCuO-based paint
- nanoTiO<sub>2</sub>-based cement
- nanoCeO<sub>2</sub>-based stain
- ...

Incidental (nano)particles

generated during the use or EoL of materials



# ERA of nanoparticles released from materials

Incidental  
(nano)particles

Nano-enabled  
products

**Short-lived  
nanomaterials**

***Relevant aging and  
exposure scenario  
in mesocosms***



# ERA of nanoparticles released from materials

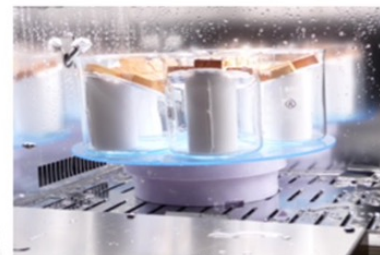
Incidental  
(nano)particles

Nano-enabled  
products

Short-lived  
nanomaterials

Long-lived  
nanomaterials

Accelerated aging testings



Multiple  
experimental  
setups exist

**Relevant aging and  
exposure scenario  
in mesocosms**



# Ex : Advanced outdoor nano-based paint with enhanced radiation efficiency

Paint application



SbD reflective mixed metal oxide ENMs



allios



# Ex : Advanced outdoor nano-based paint with enhanced radiation efficiency

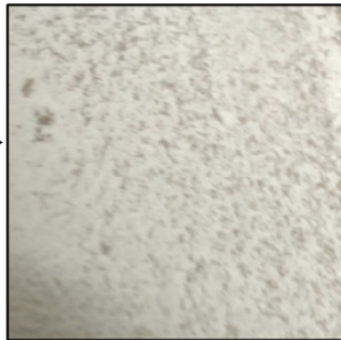
## Paint application



(I) - Three consecutive paint layers (2 hrs between each). Dry on plastic (4 d)

(II) - Cryomilling  
16000 rpm,  
N<sub>2</sub>, 80 μm sieve

## Paint fragmentation



(III) - Fine powder (> 90% recovery, no melting)

- 1 month
- 1 mg/L mixed metal oxide ENMs +/- paint





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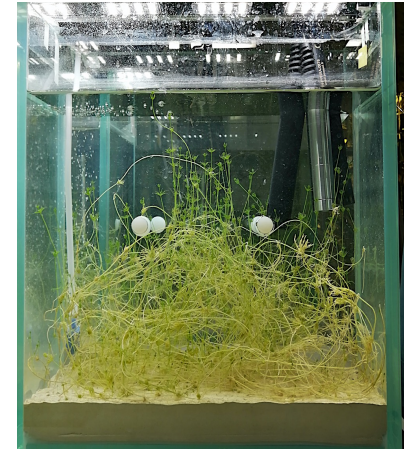
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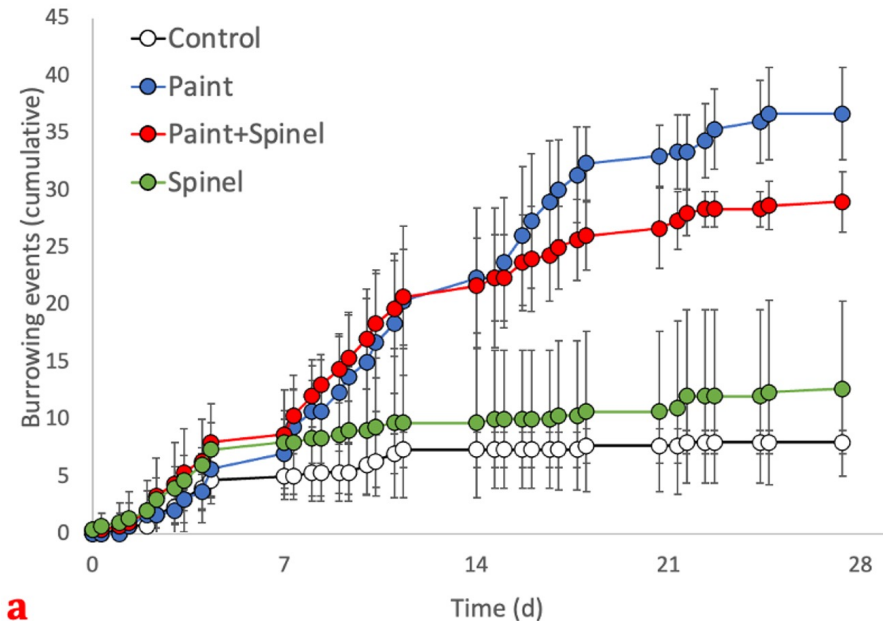


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**Matrix more than nano: the fate and impacts of the nano-based paint fragmented products is driven by the paint matrix...**



**a**



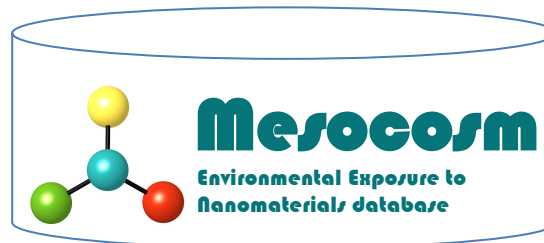


# A robust testing procedure

...adaptable to multiple exposure scenarios that produce **dependable exposure and hazard data**



Amos et al. 2021



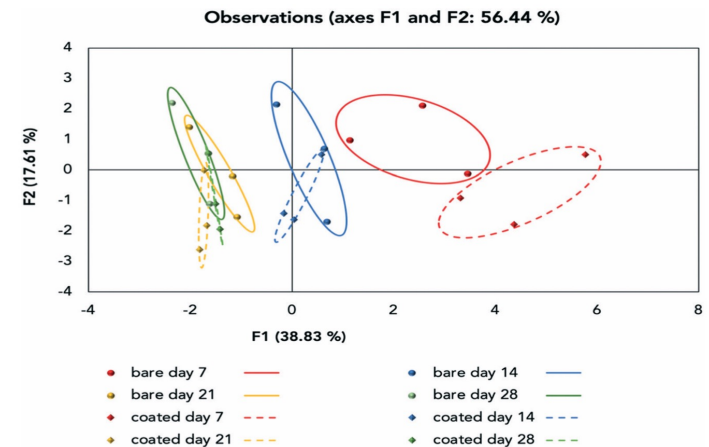
Ayadi et al. 2021



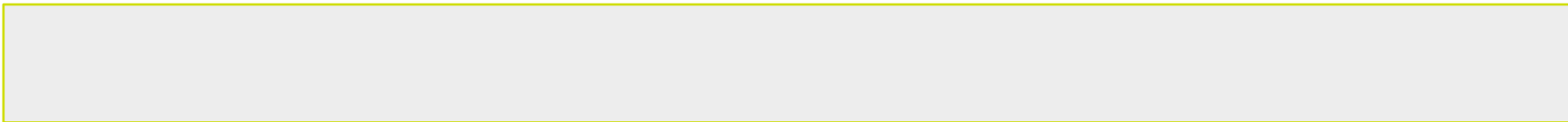
Jeliazkova et al. 2015

## Reusability

Role of multiple parameters (e.g. scenario exposure, ENM properties, mesocosms design...) on the short- and mid-term partitioning and effects of ENMs in aquatic ecosystems



Nassar et al. 2021





*What are the most critical challenges in mesocosm research and how can we overcome them ?*



Climate change



Environmental transition