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GUIDEnano

Silver nanoparticle interactions during wwtp treatment determine their environmental path

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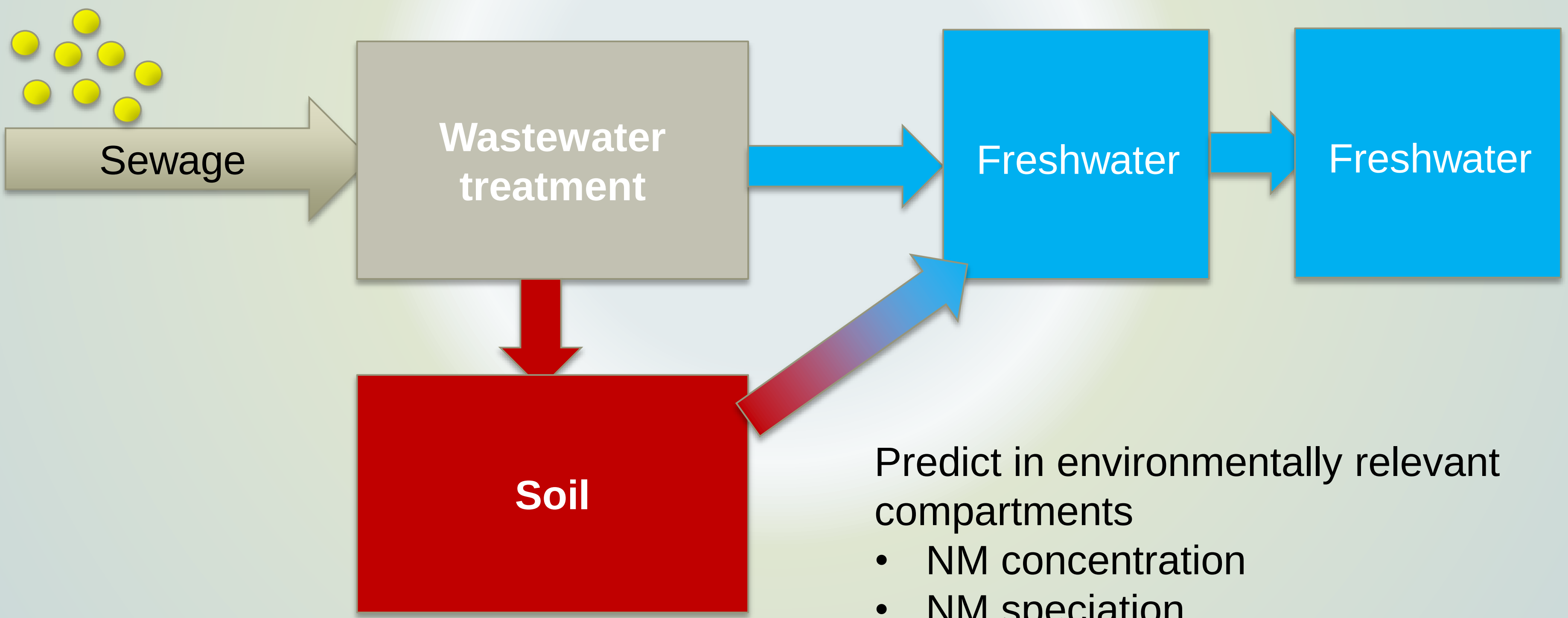
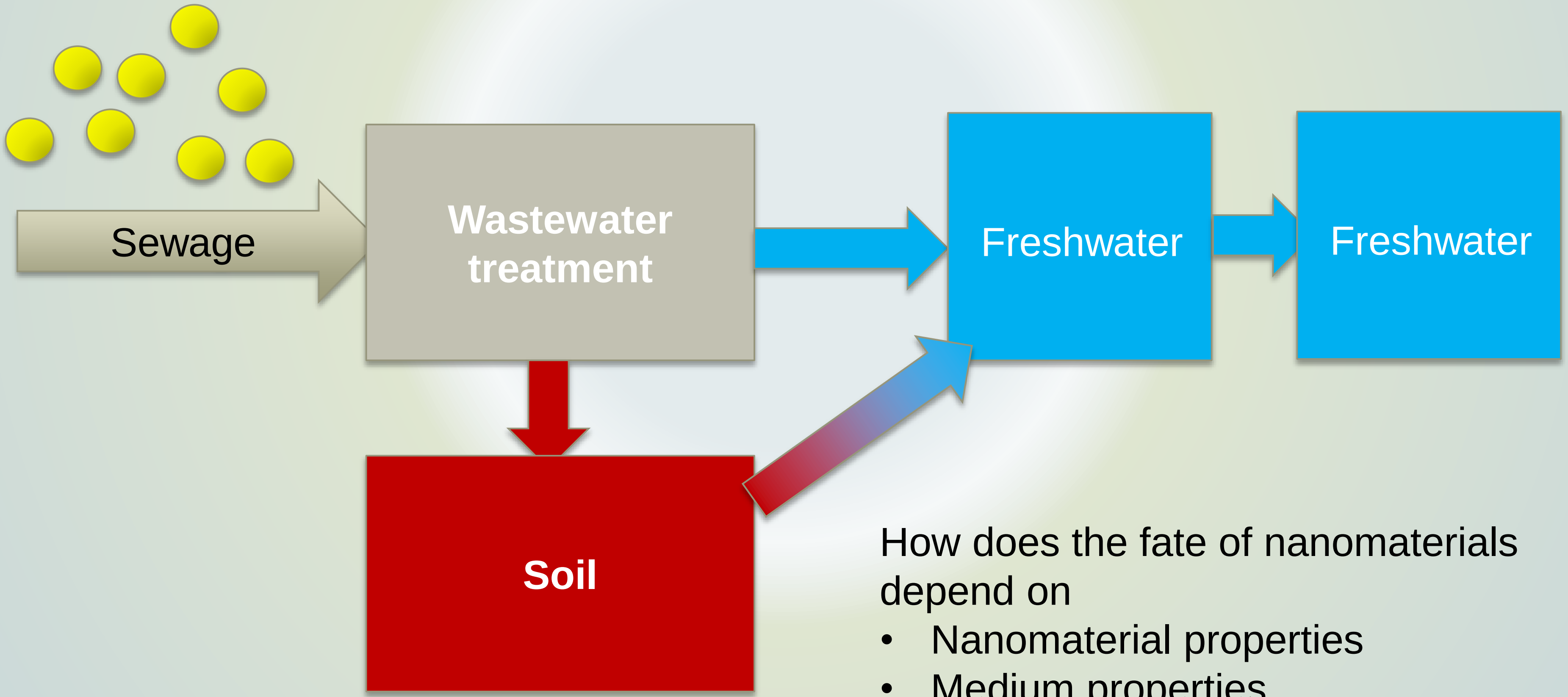
GuideNANO – fate module



Predict in environmentally relevant compartments

- NM concentration
- NM speciation
- NM risk ← Hazard prediction

GuideNANO – fate module

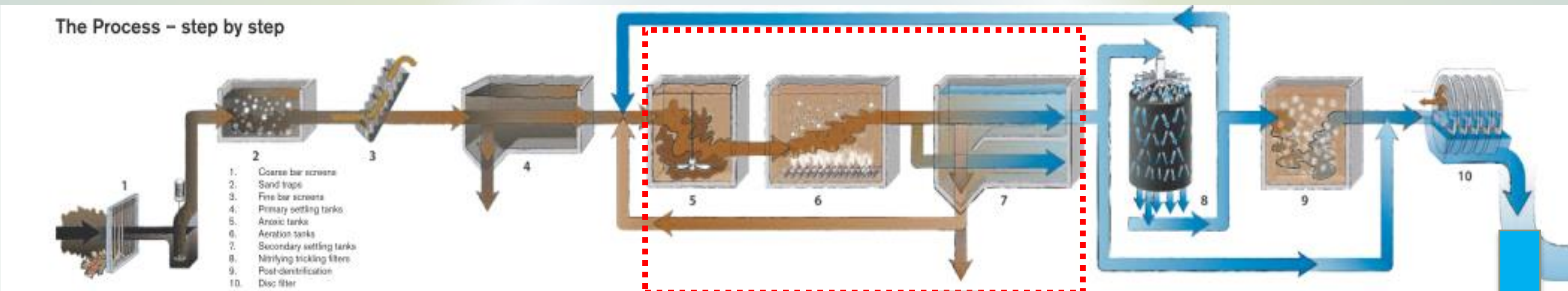


How does the fate of nanomaterials depend on

- Nanomaterial properties
- Medium properties

➔ Safe by design

Wastewater treatment



Filtering

Sand trap

Clarifier

Anoxic stage

Oxic stage

Clarifier

Nitrifying trickling filter

Denitrificatio

Primary

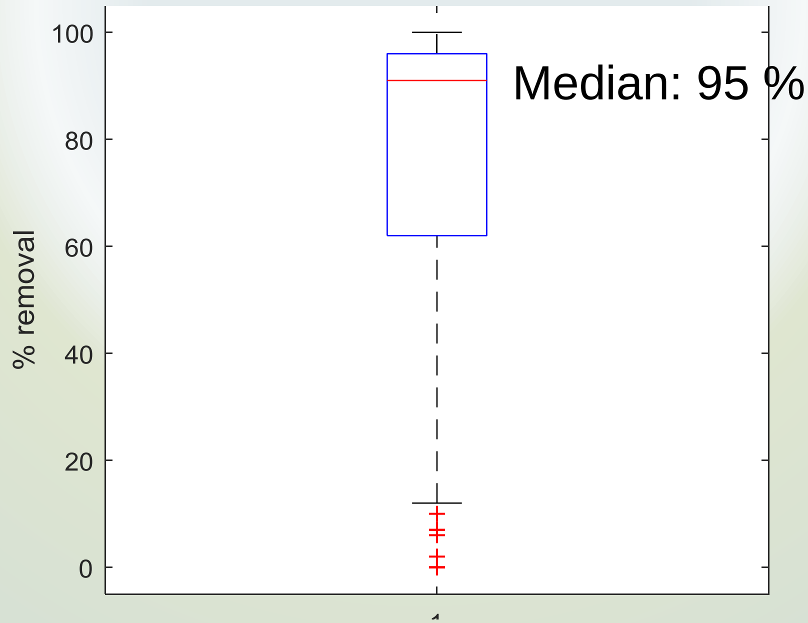
Secondary

Soil

Freshwater

Removal efficiency

135 literature values of % removal over a wide range of particle types and coatings



Influencing factors

- Attachment rate
- Residence time
- NM concentration
- [sludge]
- shear

Attachment

- % attached
- [sludge]
- Dimensions
- Time

Sedimentation

Attachment

Batch experiments

Citrate AgNP 20 nm
Citrate AgNPs 80 nm
PEG AgNP 80 nm

[Sludge] was varied by mixing UF (10 kDa) filtrates with concentrates

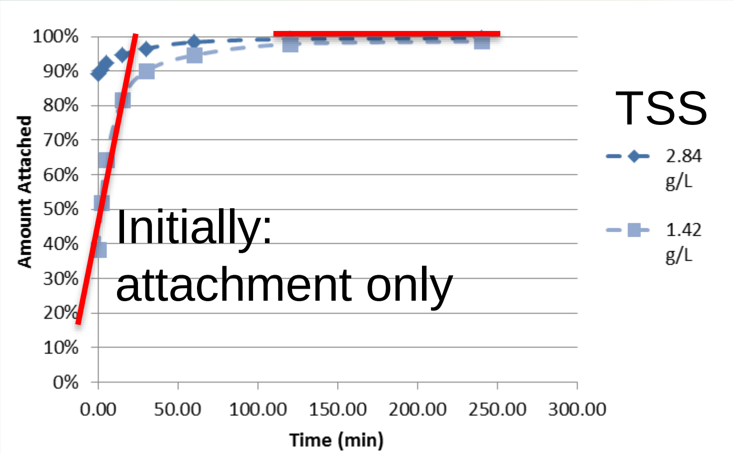
Shear was varied

Time-dependent sampling

- 0.45 µm PVDF filter
- ICP-MS (2 % HNO_3)

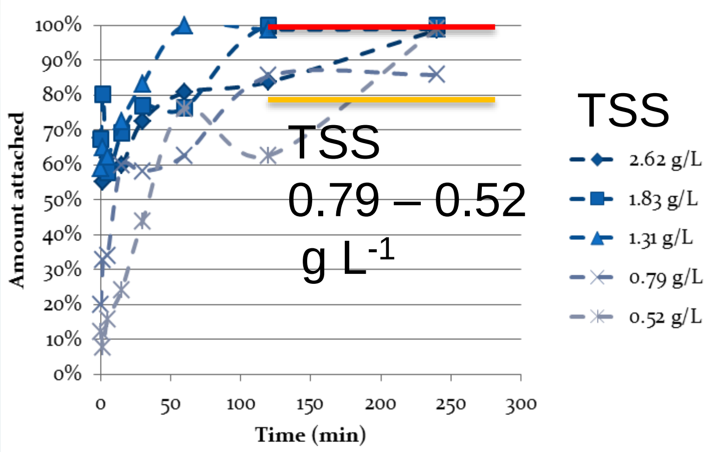
Attachment

Attach rate ~ Detach rate

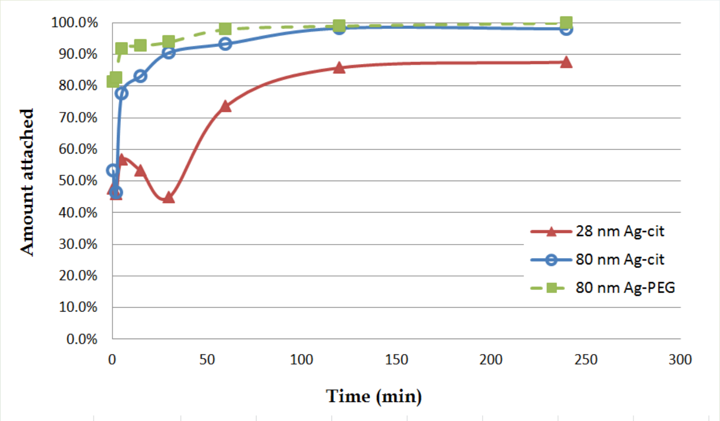


Citrate Ag 80 nm 200 rpm

TSS 2.62 – 1.31 g L^{-1}



Citrate Ag 80 nm 100 rpm



200 rpm – TSS, 3.0 g L^{-1}

- Fast attachment
- Limited effect of shear
- No effect of NM coating
- Rate ~ TSS
- Rate ~ NM primary size
- [Attached] ~ time

Sedimentation

Different NMs reacted with sludge
- Citrate coated, 28 nm
- Citrate coated, 80 nm
- PEG coated, 80 nm

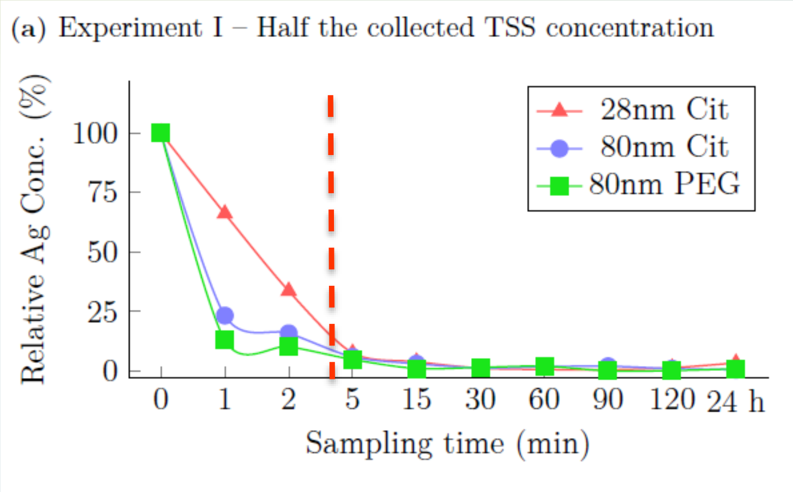
Imhoff cones
- Supernatant sampled at several time intervals at 3 cm depth

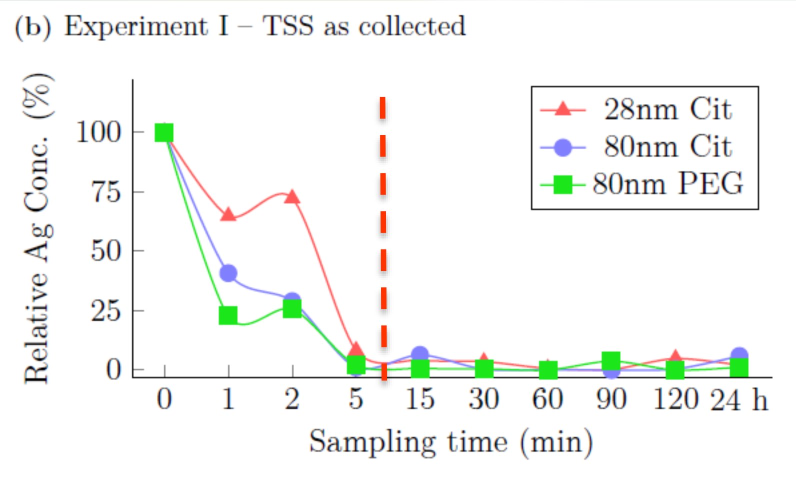
Varying [sludge]

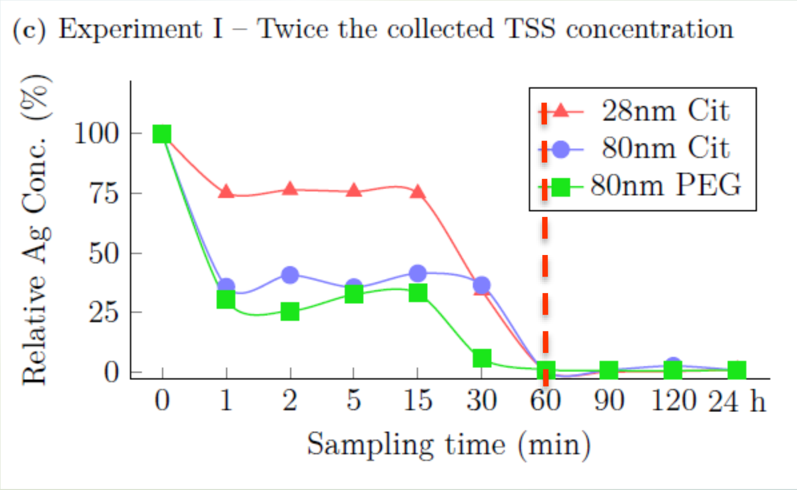
Sedimentation

No effect of coating material
Sedimentation rate ~ NM primary size
Sedimentation rate ~ 1/TSS

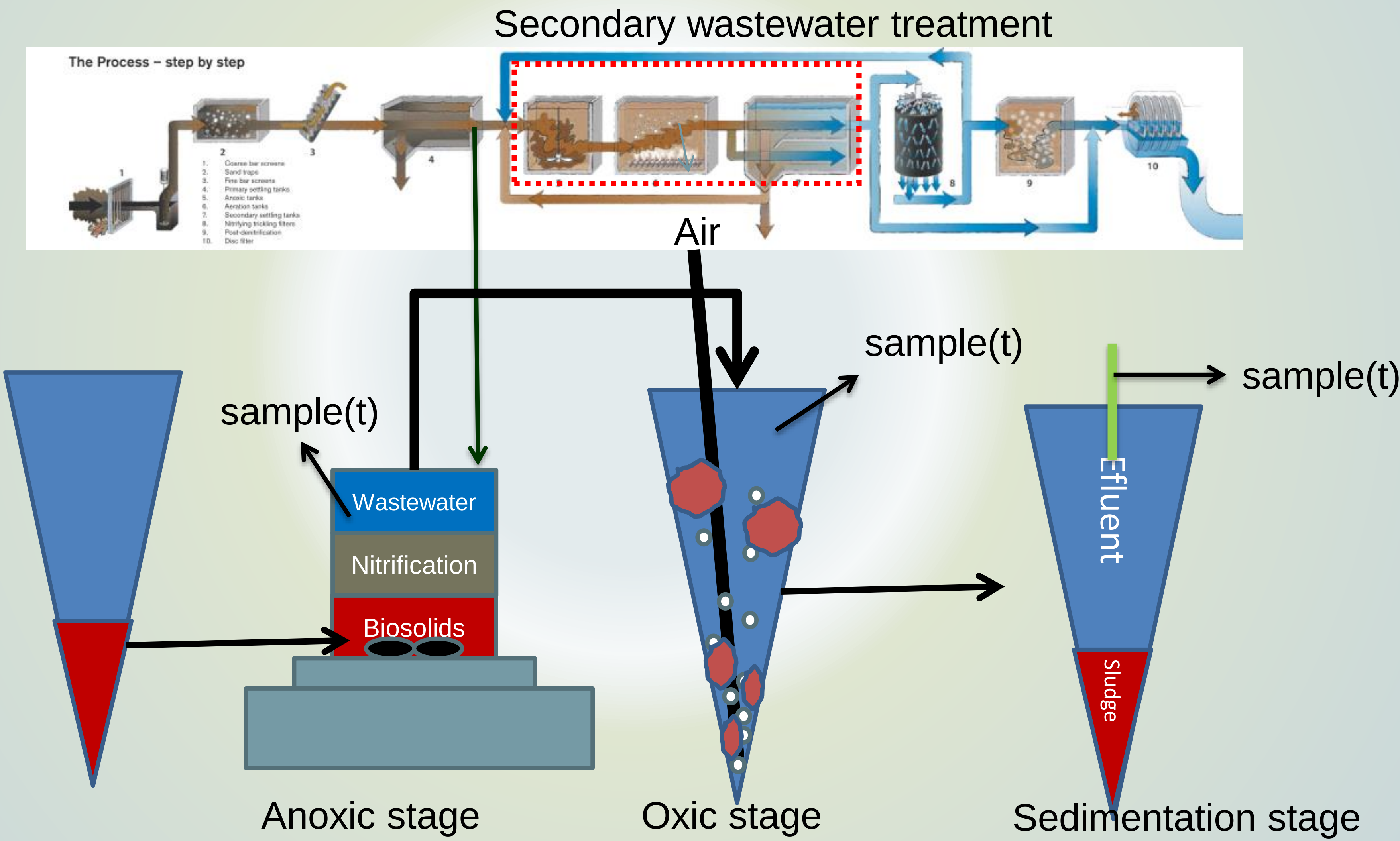
Decrease (removal) of Ag ~time
Decrease (removal) of Ag >95%



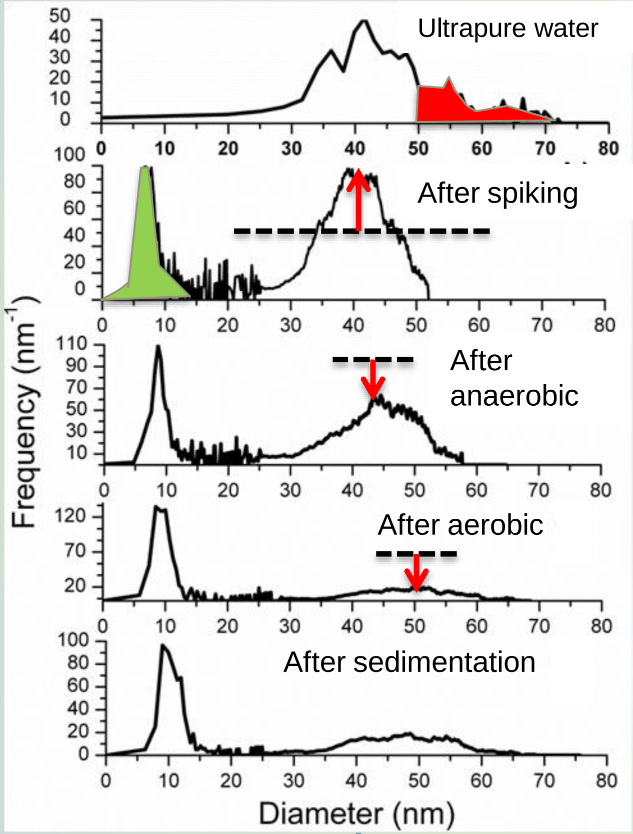




WWTP microcosm



time-dependent FAST spICP-MS



Corresponding spherical diameter

Immediately after spiking:

- De-aggregation of > 50 nm aggregates
- Occurence of a < 15 nm peak
- Dissolved Ag^+ not detectable

Loss of ”larger” nanoparticles

Much less neoformed smaller particles

Some aggregation

Conclusions

- Fast attachment kinetics followed by fast settling ➔ efficient removal of nanoparticles in WWTP
- Slightly higher persistence of smaller nanoparticles because of lower attachment rates
- Effect of coating inconsistent, possibly overgrown with DOM from wwtp
- TSS increases attachment rate but slows down sedimentation rate

10th – 12th January 2017

spICP-MS: DATA ANALYSIS WORKSHOP

RIKILT Wageningen University & Research
The Netherlands

www.nanofase.eu   empir.npl.co.uk/innanopart   www.nanodefine.eu

Day1 (10th Jan): Lectures
Day2 (11th Jan): Computer exercises
Day3 (12th Jan): Hands-on-training (*optional)*

Please register until 09.12.2016 under
http://www.wur.nl/en/activity/spICP-MS-data-analysis-workshop.htm

SLU

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Acknowledgments

Nanomaterial NANOSPHERE Risk Research

Forskningsrådet Formas

Vetenskapsrådet

NanoFASE

GUIDEnano

ACENANO

NanOFATE

MARINA
MANAGING RISKS OF NANOMATERIALS

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

Enter

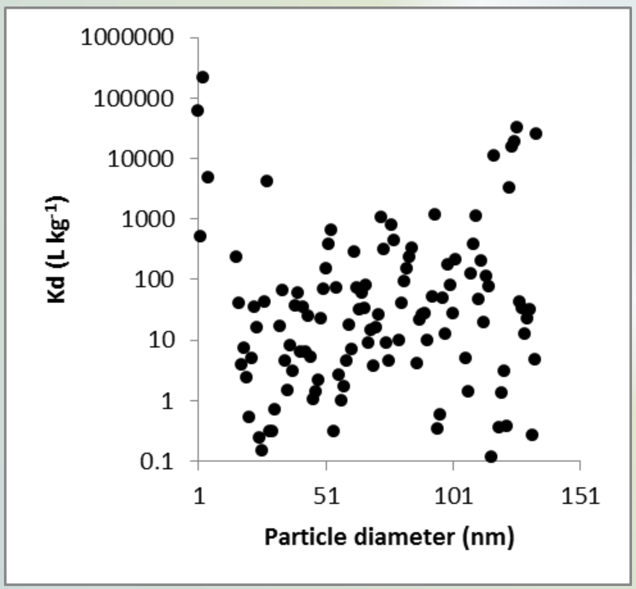
Model?

- Nanofase: 95 % partitioning, focus on stormwater overflow
- GuideNANO: steady-state situation (Hendren et al., 2013)
  - Effluent concentration :
  - Sludge concentration :

$$C = \frac{C_{in}}{1 + \frac{\theta}{\theta_x}(K_d K^* X)}$$

$$C_s = \left(\frac{C_{in}(K_d K^* X)}{1 + \frac{\theta}{\theta_x}(K_d K^* X)} \right) \cdot \rho_{sludge}$$

C_{in}: influent concentration
θ: hydraulic residence time
θ_x solid residence time
X = TSS
K*: sludge thickening factor



$$K_d = C_t \frac{P}{1-P} TSS$$

P = percentage removal