Effects of selected silver nanoparticles on freshwater microbial communities

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INTRODUCTION

- ❑ Silver nanoparticles (AgNPs) are one of the particles types with the highest production volume.
- ❑ Widespread use of AgNPs will lead to environmental release and their beneficial/wanted microbiocidal effect might become problematic in the natural aquatic environment, especially algae & bacteria might be put at risk.
- ❑ Predicted concentrations of AgNPs in surface water range from 0.1 to 1 nmol/L (Gottschalk et al. 2009, 2010,Mueller & Nowack 2008).

AIM - to answer the following questions…

- ❑ Effects on microbial freshwater communities at environmentally relevant concentrations?
- ❑ Are there any nano-specific effects?
- ❑ Are their differences in the sensitivity of biofilm algae and bacteria?
- ❑ Toxicant induced changes in the community structure?

METHODS

SWIFT periphyton assay (Porsbring et al., 2007)

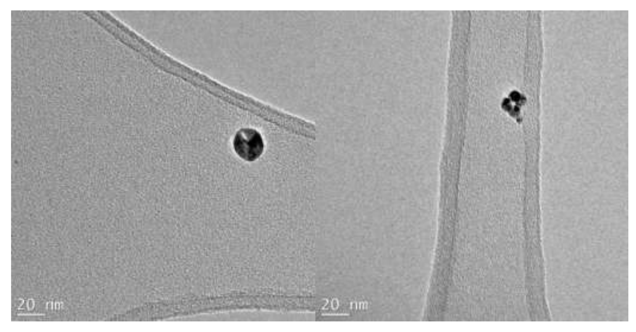
- ❑ Colonisation of glass discs by natural communities of algae and bacteria for 7-10 days in a stream.
- ❑ Toxicant exposure in the lab for 96 hours under controlled semi-static conditions (light:dark 16:8 hours, ambient temperature).
- ❑ Structural analysis of the algal & the bacterial part of the community:

Catabolic profiling & physiological activity of the bacteria using the Ecolog approach = ability to metabolise different carbon sources.

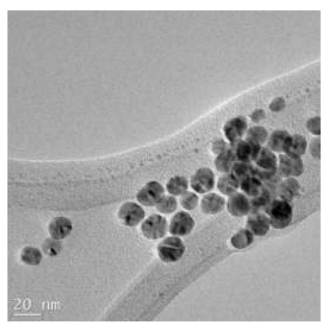
HPLC pigment profiling: Chl a content as a biomass indicator & changes in pigment patterns indicating changes in species composition and interferences with specific physiological processes.

- ❑ Analytical verification of the exposures with ICP-MS/ultrafiltration (total & dissolved silver) & NTA (agglomeration, NP behaviour, size).

Testing of two different spherical AgNPs in reference to $AgNO_3$



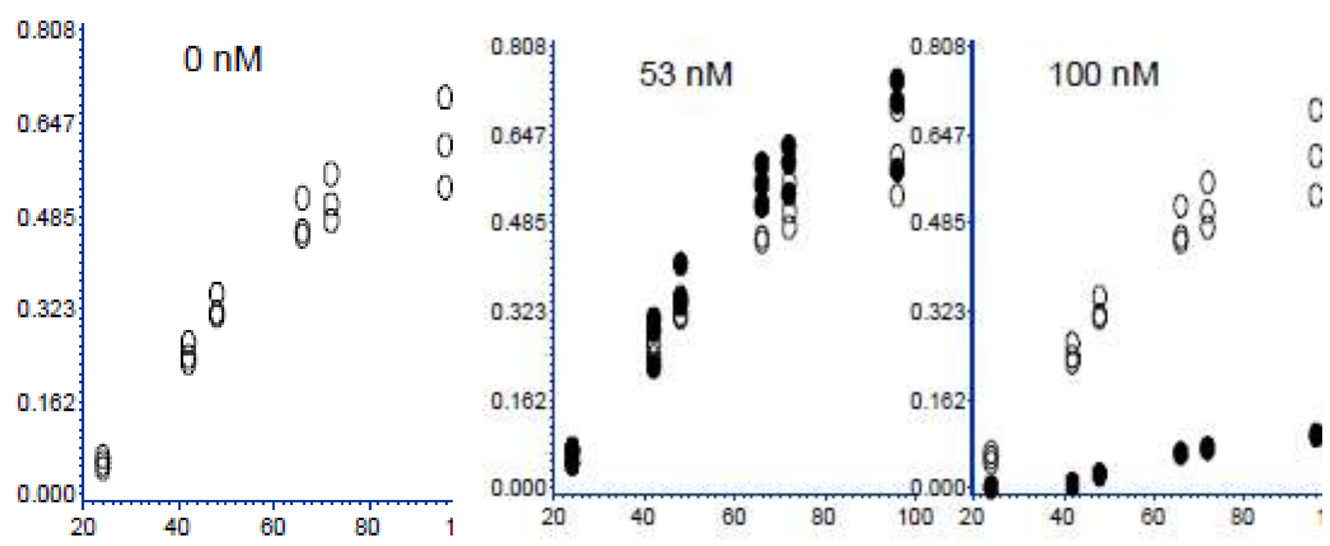
Tedpella 20 nm, citrate coated, aqueous susp. (AgNP TP)



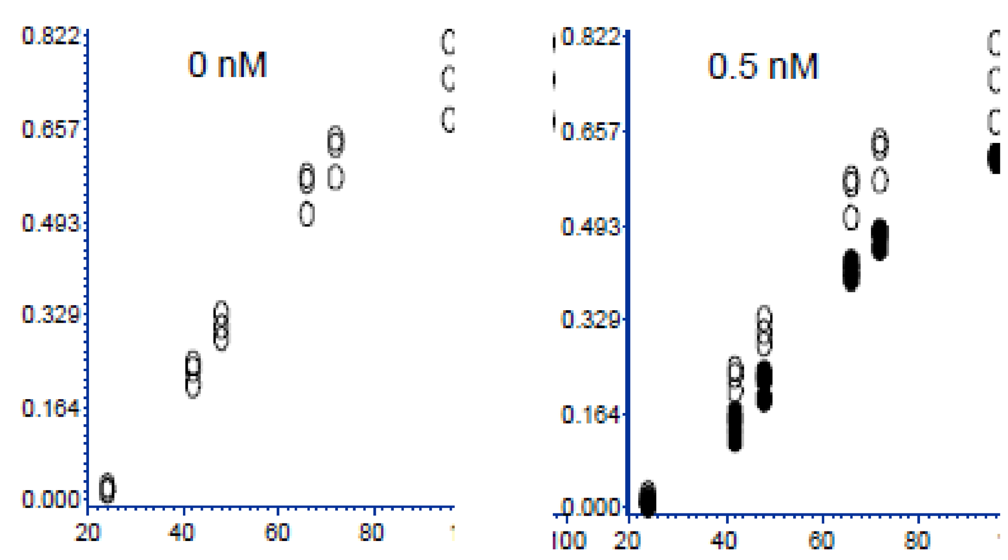
NM-300K, 20 nm, aqueous susp. & stabilizers (Tween 20) (AgNP NM-300K)

RESULTS

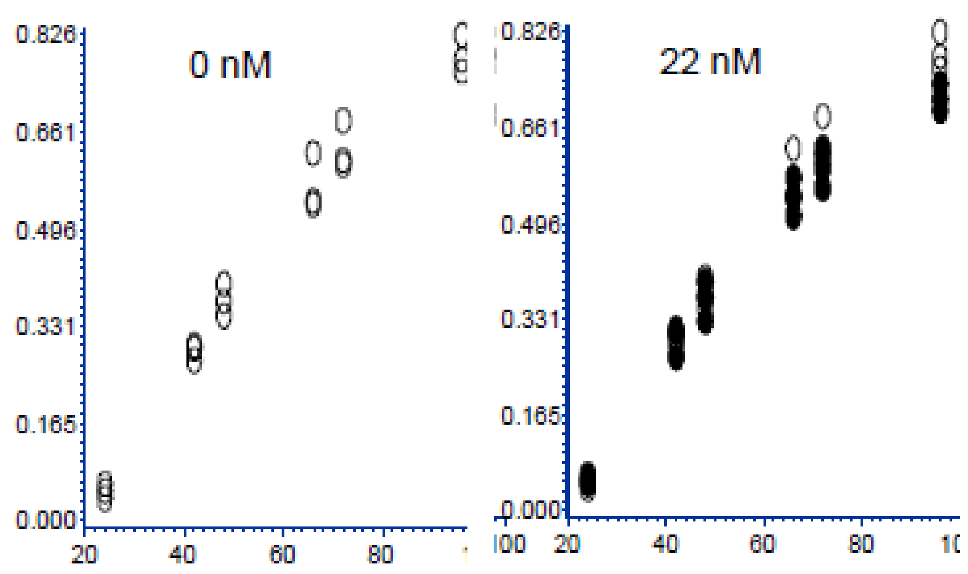
- ❑ Bacteria reacted more sensitive than algae.
- ❑ Algal part (Fig. 1): **$AgNO_3$** effects > 150 nM, **AgNP TP** (20 nm) >300 nM and **AgNP NM-300K**: > 1300 nM.
- ❑ Bacterial part (Fig. 2): **AgNP NM-300K** (20 nm) > 0.5 nM, **AgNP TP** (20 nm) > 22 nM, **$AgNO_3$** between 53 nM–100 nM.
- ❑ Comparing **$AgNO_3$** with **AgNPs**: $AgNO_3$ more toxic for the algae, AgNPs more toxic for the bacteria.
- ❑ **Agglomeration/size:** particle background in the natural river water too high to differentiate between natural & ENPs.
- ❑ **Total silver:** variation between nominal and real Ag conc. NM-300K accumulation over test time (4 days).
- ❑ **Dissolved silver:** **$AgNO_3$**: decreasing conc. – due to precipitation? River water slows down the particle dissolution, but **NM-300K** higher dissolution than **AgNP TP**.



a) $AgNO_3$



b) AgNP NM-300K (20 nm)



c) AgNP Tedpella (20 nm, citrate coated)

Fig 2: Average well colour (AWC) development in the Ecologplates over time for selected concentrations of a) $AgNO_3$ b) AgNPs NM-300K c) AgNPs TP; x-axis: time in hours, y-axis: OD of the colour development at 595 nm

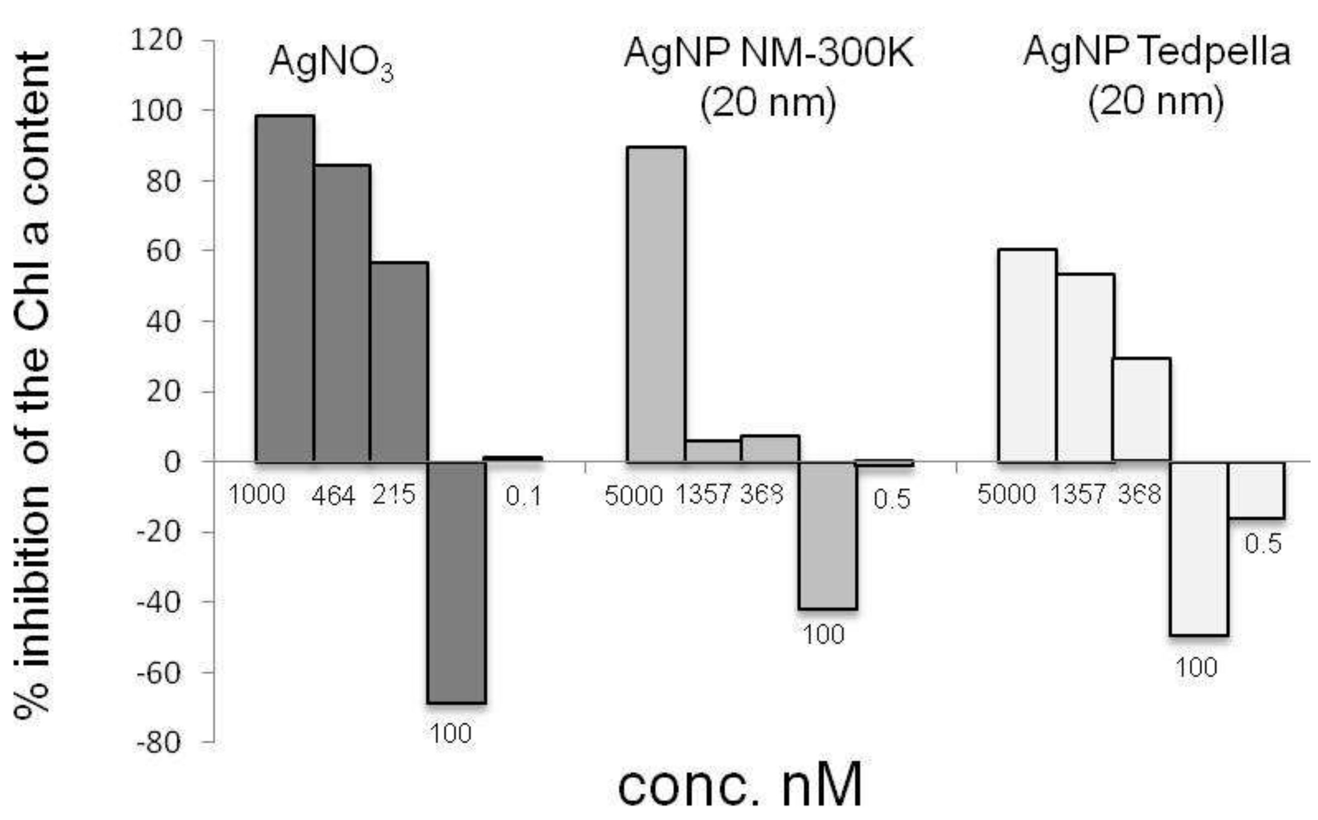
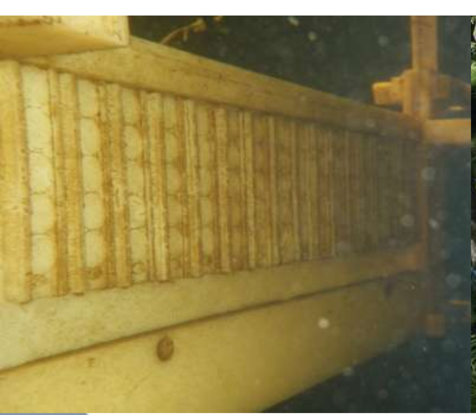


Fig. 1: % Inhibition of the Chlorophyll a (Chl a) content for 5 different concentrations of $AgNO_3$ and AgNPs

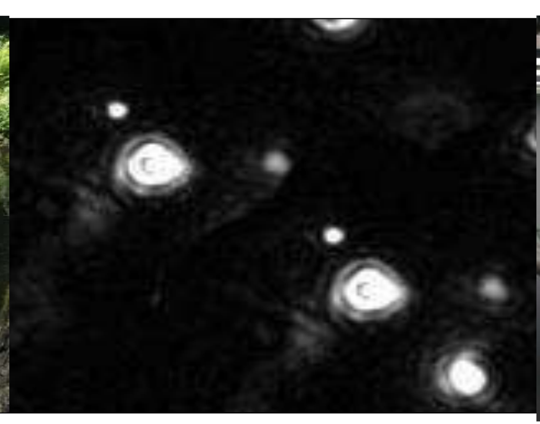
CONCLUSIONS & OUTLOOK

- ✓ Bacteria more sensitive than algae with effects for the NM-300K in the range of environmental realistic concentrations.
- ✓ Analytics crucial for a correct interpretation of the ecotoxicological results– otherwise underestimation of theAgNPs effects and hazards; data patterns highly complex.
- ✓ Indications for nanospecific effects: higher toxicity of the AgNPs than the $AgNO_3$ for the bacteria.
- ✓ Further analysis & link of ecotox & analytics data necessary.

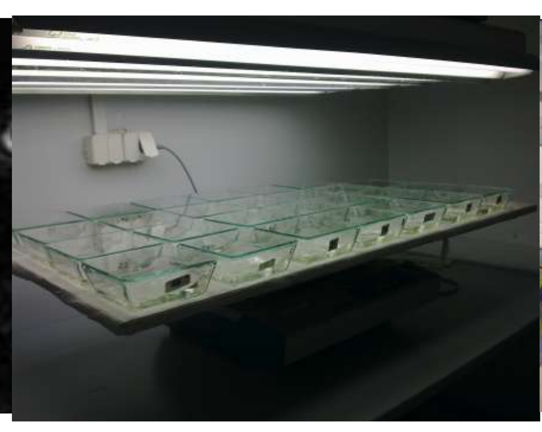


Sampling of natural biofilm

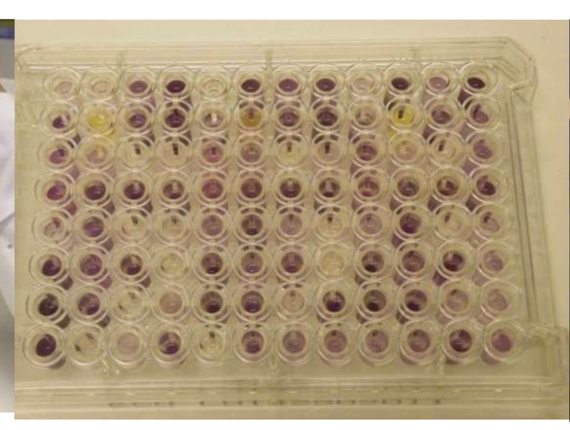
Field site



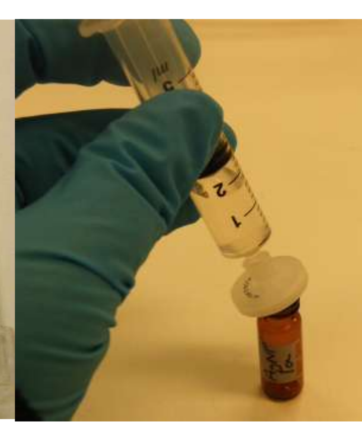
NanoSight



Climate room for exposure



Ecolog plates (bacterial part of the community)



Filtering pigment samples for HPLC

Periphyton on glass discs

References

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Acknowledgements

Funded by Nanosphere (FORMAS, The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning) and Nanofate (EU Commission, FP7)

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