Effects of silver nanoparticles on freshwater microbial communities

Marianne Matzke[1,4], Julian Gallego[2], Martin Hassellöv[2], Kerstin Jurkschat[3], Thomas Backhaus[4]
[1] Centre of Ecology and Hydrology (CEH), Maclean Building, Crowmarsh Gifford, United Kingdom
[2] Department of Chemistry, University of Gothenburg, Sweden
[3]Department of Materials, Oxford University, Begbroke Science Park, United Kingdom
[4] Department of Biological and Environmental Sciences, University of Gothenburg, Sweden
e-mail: martzk@ceh.ac.uk

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

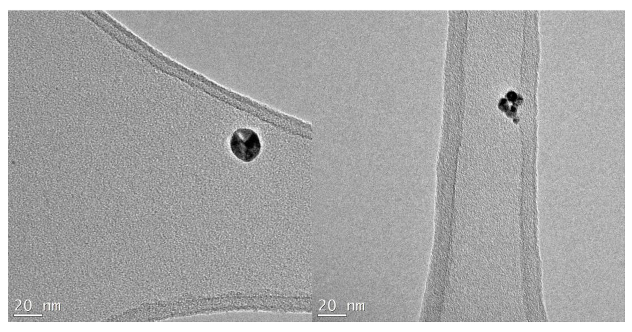
SWIFT periphyton assay according to Porsbring et al., 2007

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

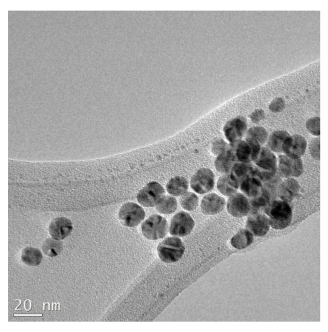
 Catabolic profiling & physiological activity of the bacteria using the Ecolog approach = ability to metabolise different carbon sources.
 HPLC pigment profiling: Chl a content as a biomass indicator & changes in pigment patterns indicating changes in species composition and interferences with specific physiological processes.

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

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



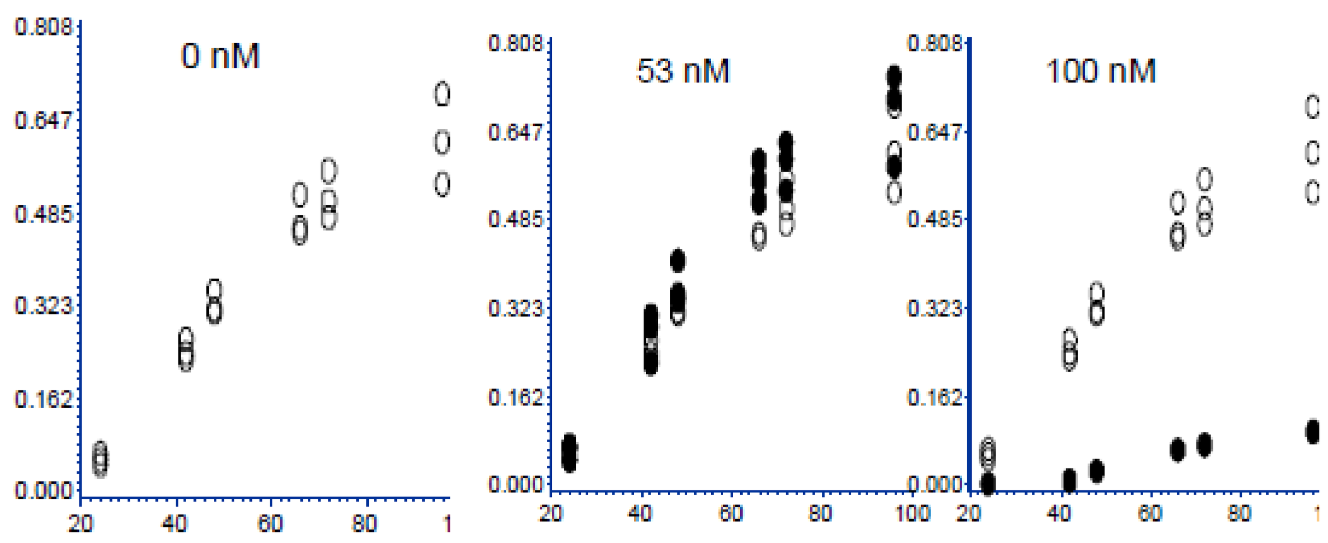
Tedpella 20 nm, citrate coated, aqueous suspension (AgNP TP)



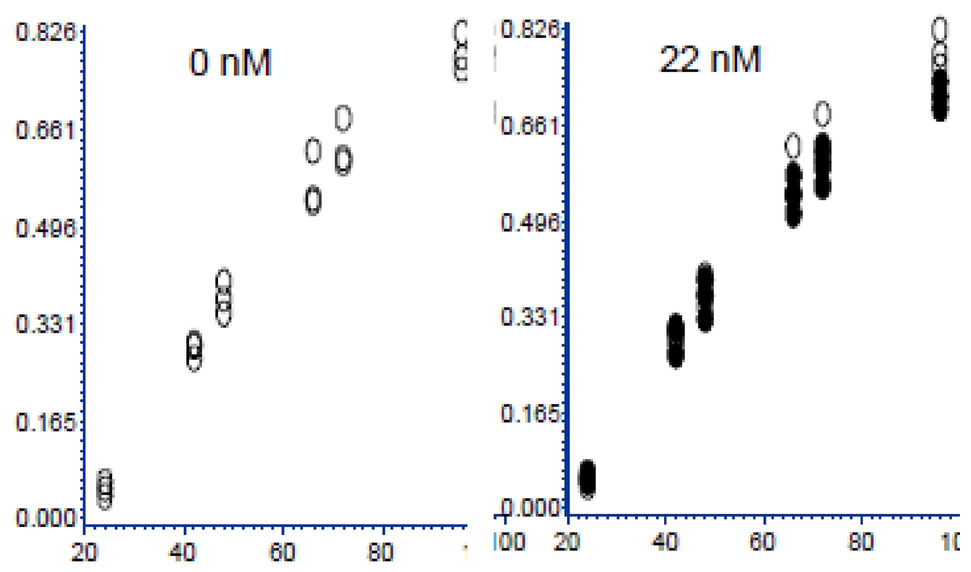
OECD particles NM-300K, 20 nm, aqueous suspension with stabilizers (Tween 20) (AgNP NM-300K)

RESULTS

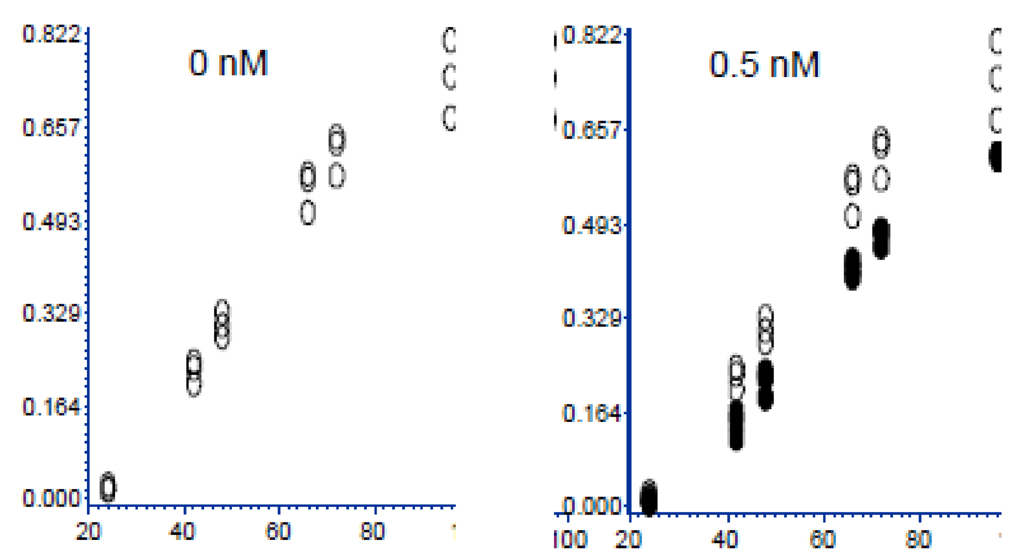
- Bacteria reacted more sensitive than algae.
- Bacterial part (effects based on average well colour development (AWC), Fig. 1): **AgNP NM-300K** (20 nm) > 0.5 nM, **AgNP TP** (20 nm) > 22 nM, **$AgNO_3$** between 53 nM – 100 nM.
- Algal part (effects based on Chl a content, Fig. 2): **$AgNO_3$** effects > 150 nM, **AgNP TP** (20 nm) > 300 nM and **AgNP NM-300K**: > 1300 nM.
- Comparing $AgNO_3$ with AgNPs: $AgNO_3$ more toxic for the algae, AgNPs more toxic for the bacteria.
- Analytics suggest differences between nominal and real concentrations in terms of total and dissovled silver.



a) $AgNO_3$



b) AgNP Tedpella (20 nm, citrate coated)



c) AgNP NM-300K (20 nm)

Fig 1: Average well colour (AWC) development in the Ecologplates over time for selected concentrations of a) AgNO3 b) AgNPs TP c) AgNPs NM-300K, x-axis gives time in hours, y-axis OD of the colour development at 595 nm

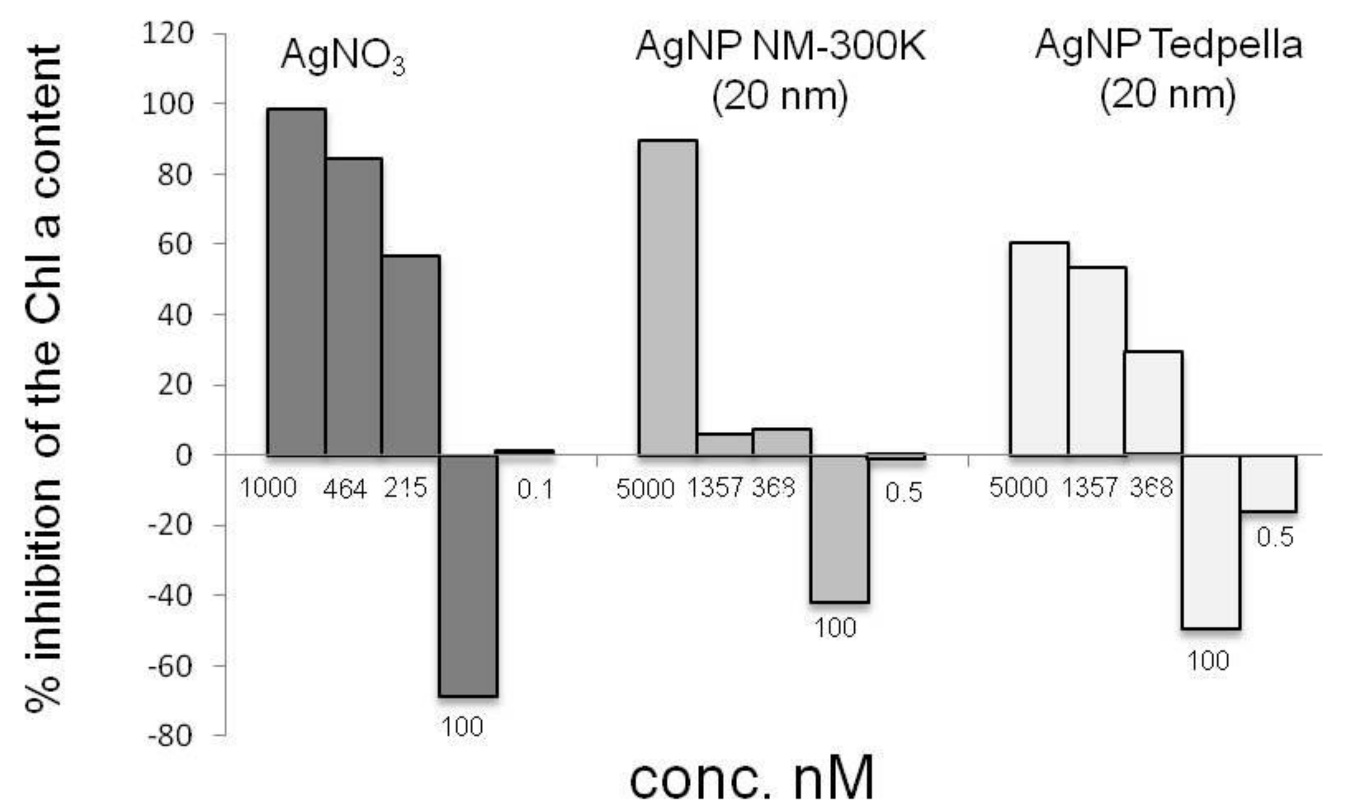
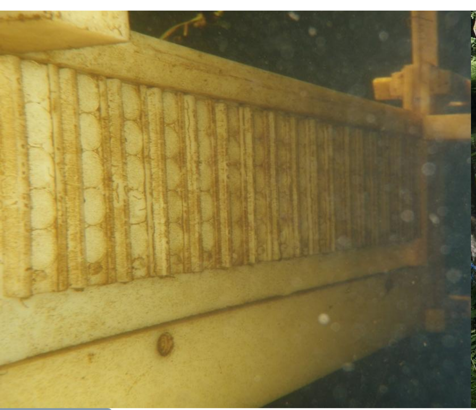


Fig. 2: % Inhibition of the Chlorophyll a (Chl a) content for 5 different concentrations of $AgNO_3$ and AgNPs

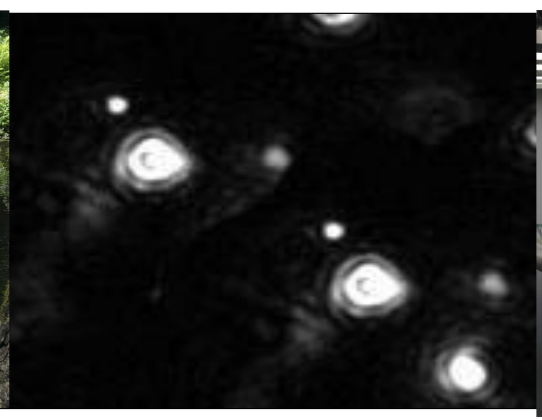
CONCLUSIONS & OUTLOOK

- ✓ 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.
- ✓ Indications for nanospecific effects: higher toxicity of the AgNPs than the $AgNO_3$ for the bacteria.
- ✓ Link of the ecotoxicological and analytical data (ICP-MS, NTA and MinteQ modelling).

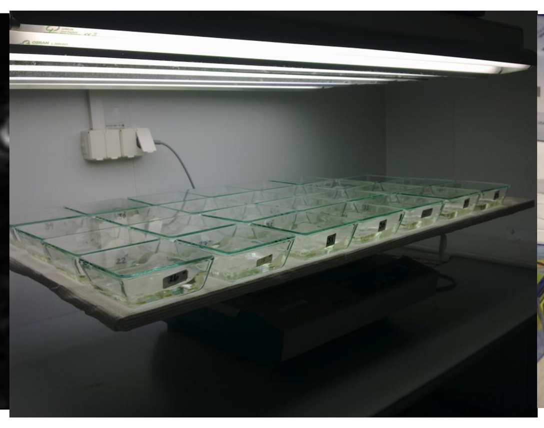


Sampling of natural biofilm

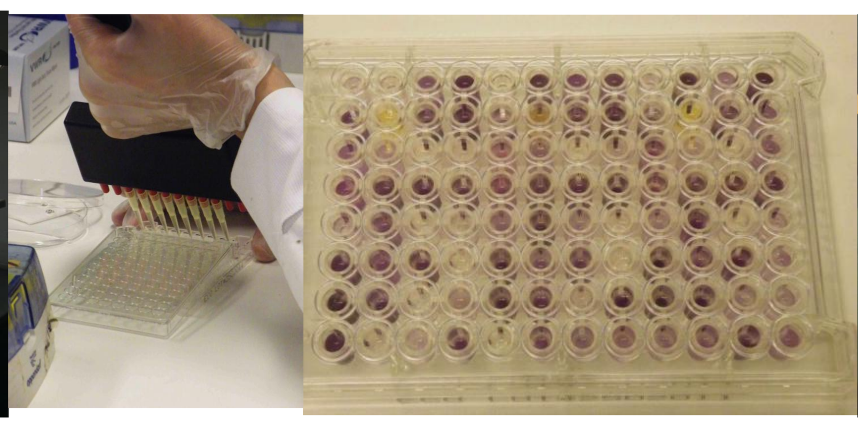
Field site



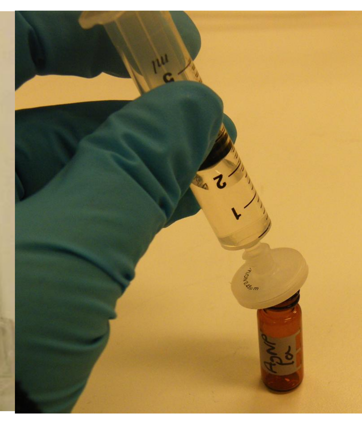
NanoSight



Climate room for exposure



Ecolog plates (bacterial part of the community)



Filtering pigment samples for HPLC

Periphyton on glass discs

References

Gottschalk, F. et al., 2009. Modeled environmental concentrations of engineered nanomaterials (TiO(2), ZnO, Ag, CNT, Fullerenes) for different regions. Environmental science & technology, 43(24)
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Mueller, N.C. & Nowack, B., 2008. Exposure modeling of engineered nanoparticles in the environment. Environmental science & technology, 42(12), pp.4447-53.

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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)