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Bioaccumulation and effect of sediment-associated silver in different forms in two marine deposit feeders

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Introduction
• Different behaviour and effects of metal-bearing nanoparticles (NPs) have been found compared to their corresponding metallic ions [1,2].
• Toxicity of metal-bearing NPs isn’t easily predicted when comparing to corresponding ionic form
• It is unclear whether toxicity of metal-bearing NPs is dependent on particle size.
The aim of our study is to examine effects at the individual level by measuring typical endpoints in two organisms (i.e., a marine polychaete, Capitella teleta and a marine bivalve, Macoma balthica) after exposure to sediment amended with different forms and particle sizes of Ag.

Hypothesis:
Toxicity and biota is metal form/particle size dependent? (Here are their relative differences in size)

• Ionic
• Nano-particle
• Micron-sized particle

Result – Macoma balthica
Toxicity
No negative effects were detected on mortality, condition index or growth of exposed clams for any Ag form (data not shown).
Bioaccumulation
Bioaccumulation of Ag in M. balthica decreased significantly with increasing particle size (One-way ANOVA, p = 0.03) (Figure 1).

Experimental design
Capitella teleta exposure (for 14 d):

<table>
<thead>
<tr>
<th>Ag+</th>
<th>30nmNPs(Sigma)</th>
<th>100nmNPs(JRC)</th>
<th>Micron-Ag(Sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31%S</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Macoma balthica exposure (for 35 d):

<table>
<thead>
<tr>
<th>Ag+</th>
<th>20nmNPs(Sigma)</th>
<th>40nmNPs(Sigma)</th>
<th>Micron-Ag(Sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17%S</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Endpoints • Mortality • Growth • Health condition • Body burden

Result – Capitella teleta
Toxicity
No significant effects on either mortality or specific growth rate were detected for any Ag form or nominal concentration (data not shown).
Bioaccumulation
There was no significant effect of Ag form on Ag accumulation in C. teleta, although body burden increased significantly as a function of nominal concentration (One-way ANOVA, p < 0.001) (Figure 2).

Figure 1. Silver concentration measured in Macoma balthica exposed to a nominal conc. of 20µg/g dw sed. *** refers to a significant difference from ionic Ag. Error bars indicated 1 standard deviation (n=5).

Figure 2. Silver concentration measured in Capitella teleta exposed to nominal concentration of 10, 50 and 100 µgAg/g dw sed. Error bars indicated 1 standard deviation (n=6). 20 nm nanoparticle at 100µg dw sed nominal concentration was removed due to a significant difference in initial measured Ag concentration from the other treatments with the same nominal concentration at day 0.

Conclusions
• No significant effects on mortality and growth of C. teleta and M. balthica.
• All Ag forms are bioavailable to both organisms.
• Metal form/particle size dependence of bioavailability is species specific, possibly due to differences in:
  • gut structure, thus
  • particle sorting mechanisms

Such differences in the bioavailability of metal-bearing particles warrant further investigation and consideration in terms of the impact of them in sediment environments.

References
2. Cong, Y., Banta, G.T., Selck, H., Berhanu, D., Valsami-Jones, E. (2011). The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n – 214478 (NanoReTox).