Advanced research on nickel toxicity in sediment: species, bioavailability and toxicity

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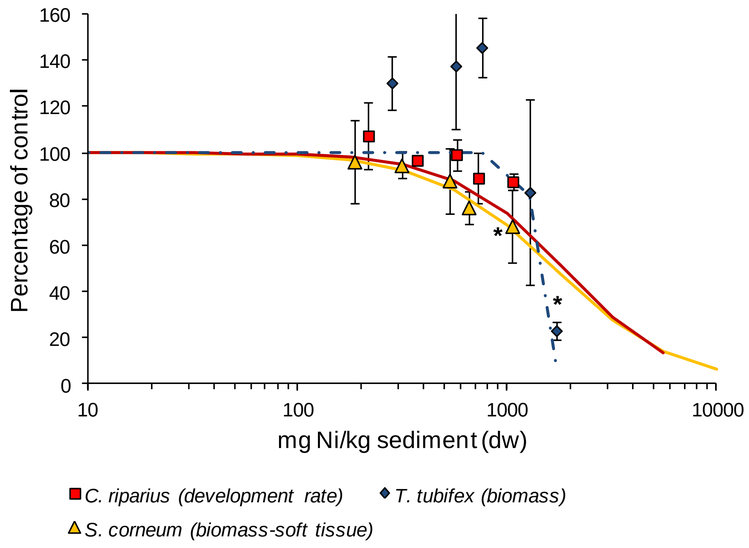
Introduction

Sediment toxicity is known to be affected by abiotic factors such as the concentrations of Total Organic Carbon (TOC) and Acid Volatile Sulphides (AVS) in the sediment, but also by biotic factors such as the intrinsic sensitivity and the behaviour of test species. In this study, the sensitivity to nickel toxicity was evaluated for several benthic species representing different taxonomic groups and life styles. A natural sediment with low binding capacity (i.e. low TOC and AVS) was used.

Materials & Methods

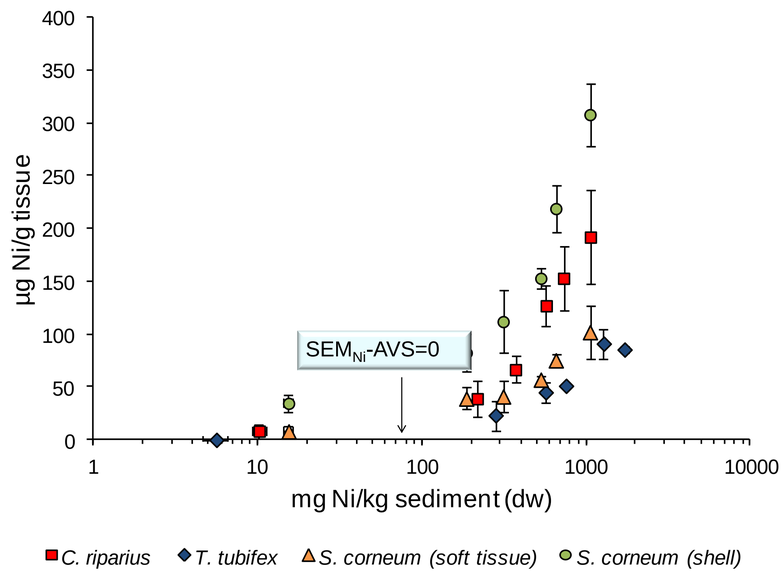
- 28-d sediment exposure with *Tubifex tubifex*, *Chironomus riparius, Lumbriculus variegatus* and 35-d sediment exposure with *Sphaerium corneum*
- Sediment: Acid Volatile Sulphide (AVS): 1-2 µmol/g, Simultaneously Extracted Metals (SEM): 0.5 µmol/g, organic carbon: 1.5%
- Flow-through system (8 volumes renewed/day)
- Daily feeding with TetraMin® (200 – 500 µg/organism)
- Ni spiked sediments were equilibrated for 4-6 months; indirect spiking method [1]; nominal Ni concentrations: 180 – 3,200 mg/kg
- Measurements: survival, growth, development rate and metal body burdens
  AVS; Ni in sediment, pore water, SEM (t=0, 28 and 35d) and in overlying water (t=0, 7, 14, 21, 28 and 35d)
- Micro X-ray fluorescence (XRF) measurements are used to analyse the internal distribution of Ni
- ANOVA, significance level set at p = 0.05

Results & Discussion



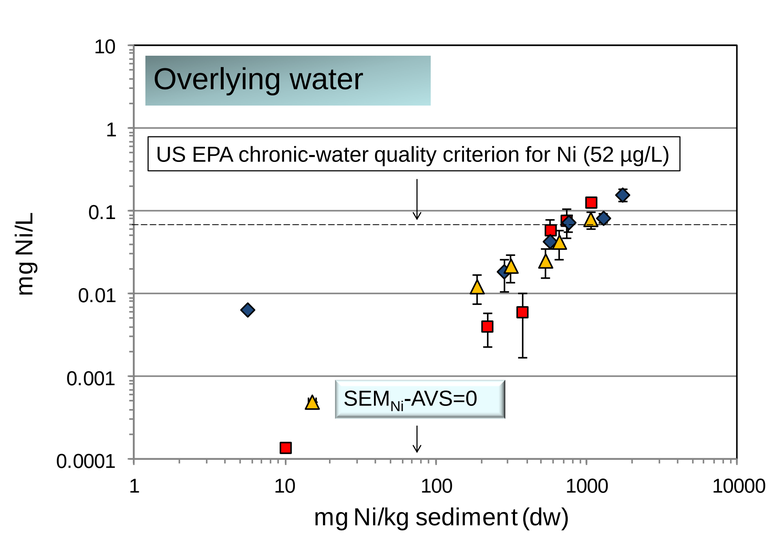
Toxicity of Ni to three species (mean ± sd; n=3)
***: significantly different from the control**

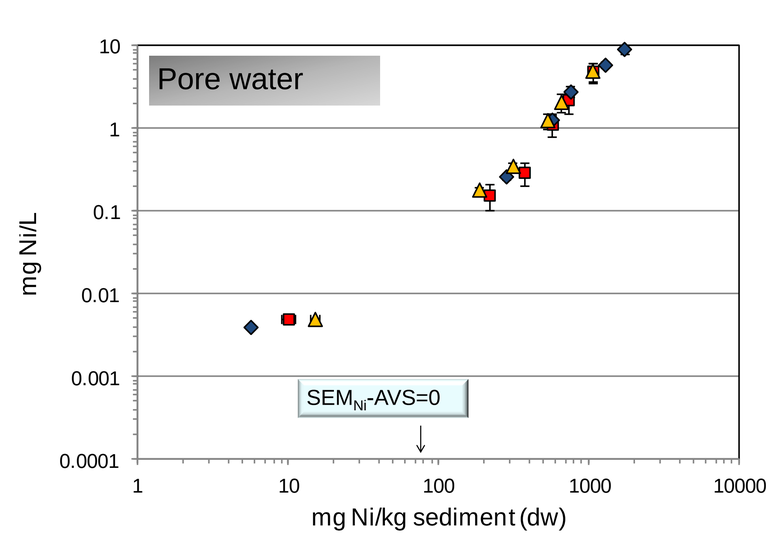
EC_{10} (95% CL) (mg Ni/kg sediment)		
	T. tubifex	1,103 (883-1,379)
	C. riparius	762 (324-1,788)
	S. corneum	388 (123-1,229)



Ni body burdens of C*. riparius, T. tubifex* and *S. corneum* as a function of Ni in the sediment (mean ± sd; n=3).

At SEM_{Ni}-AVS>0, a significant increase in Ni body concentrations with increasing Ni sediment concentrations was noted.



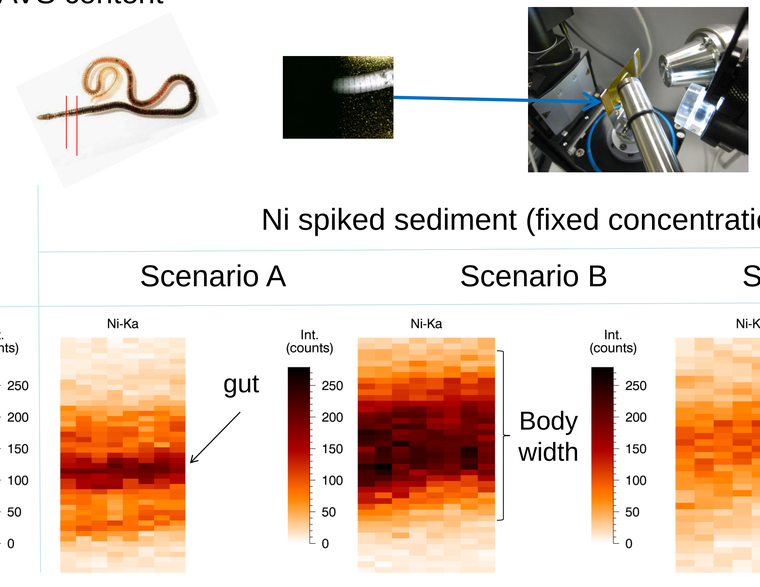


Ni concentration in the overlying water and pore water during the toxicity tests (mean ± sd; n≥3).

XRF analysis

Lumbriculus variegatus worms exposed to Ni under different feeding scenarios and in different sediments varying in AVS content

Narrow body sections scanned with 2D-XRF



- Clear detection of Ni in exposed worms
- Different distribution and/or concentration of Ni depending on exposure scenario

Conclusions

The results support the basis of the SEM-AVS concept, as it reflects the absence of toxicity at SEM-AVS < 0 for all species. A clear accumulation of Ni was found once SEM-AVS >0. The internal distribution of Ni over the body tissue was dependent on the exposure scenario. In on-going and future experiments, additional species and sediments will be evaluated and tomography XRF analysis will reveal more detailed tissue distributions.

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[1] Besser et al. (2011). Toxicity of Nickel-spiked freshwater sediments to benthic invertebrates – Spiking methodology, Species sensitivity and Nickel bioavailability. USGS – NiPERA. Report 2011-5225.