# The use of meiofauna in freshwater sediment assessments: community responses to contamination

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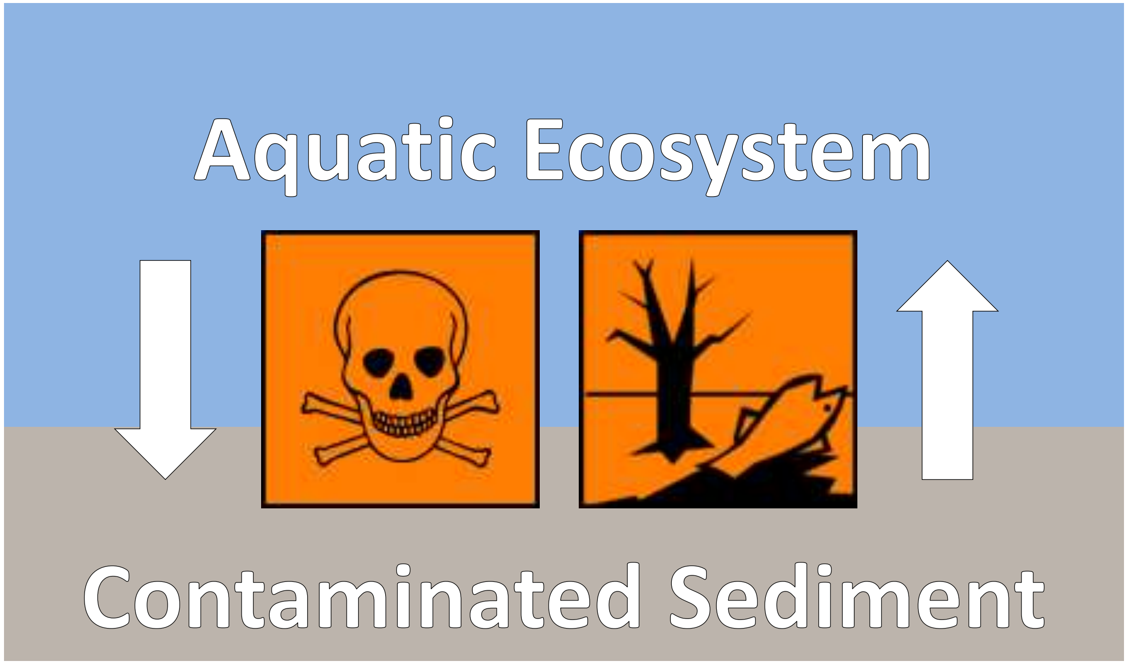
Universität Bielefeld

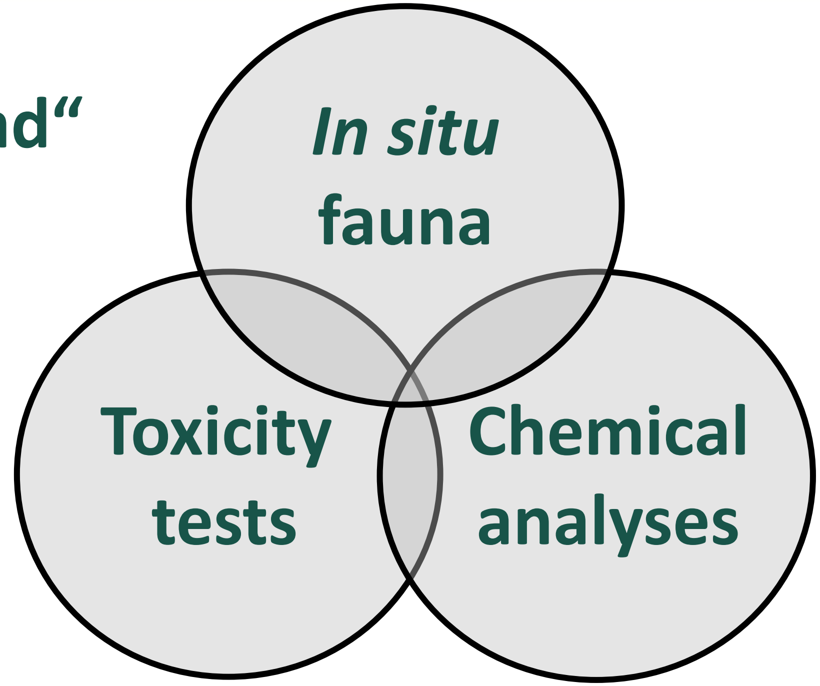
ecossa ecological sediment & soil assessment

bfg Bundesanstalt für Gewässerkunde




- → **Contaminated sediments prevent "good ecological status" (WFD)**
- → **Sediments act as sinks and sources**
- → **Soft (fine & sandy) sediments of particular concern**

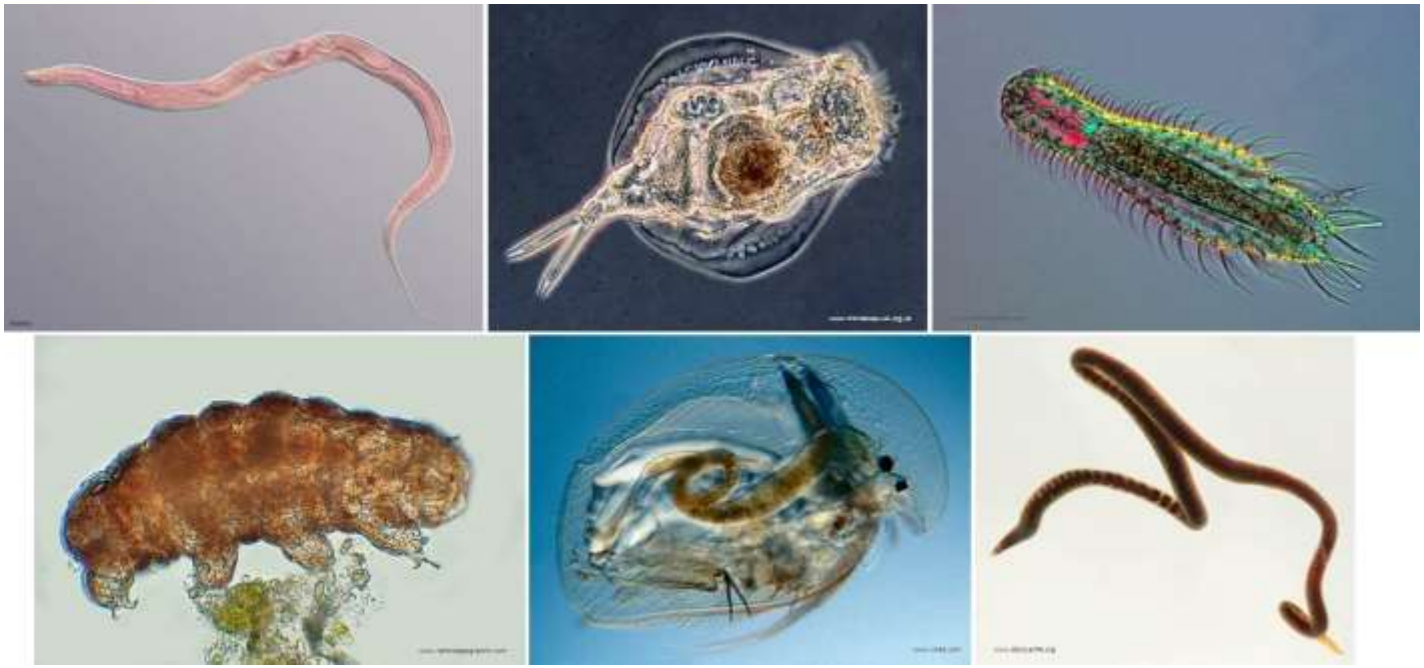
## „Sediment Quality Triad“
(Long & Chapman, 1985)




→ “Weight of evidence” approaches highly recommend

→ Benthic organisms strongly associated to contaminants

→ Widely based on macrofauna (e.g., SPEAR[%]-index)



→ Soft sediments host specific invertebrate communities

→ Meiofauna > macrofauna

→ Meiofauna restricted to interstitial/burrowing lifestyle

→ Bioindication with meiofauna advantageous

→ Nematodes dominant among the meiofauna

→ Ubiquitous, very high abundances (>1.000.000/$m^2$)

→ Key position in benthic food web

→ Predestined for bioindication

# Objectives of the study:

→ To assess the general sensitivity of meiofaunal communities and particular parameters to chemical contamination

→ To evaluate the suitability of nematodes as bioindicators

→ To determine whether lower testing tiers are both representative and capable of estimating the impact of sediment contaminants on higher levels of biological organization

**Pristine sediment**

**Microcosms:**

→ **8 substances**

- **Exp. 1: Cu, Zn & FA**
- **Exp. 2: Ni, BaP, Met-Mix, PAH-Mix & PAH/Met-Mix**

→ **180 d (3 sampling dates)**

**Analyses:**

→ **Meiofauna/Nematodes**

- **Abundance**
- **Biomass**
- **Taxa/Species composition**

→ **Sediment**

- **Chemical analyses**
- **Toxicity analyses (ISO 10872)**

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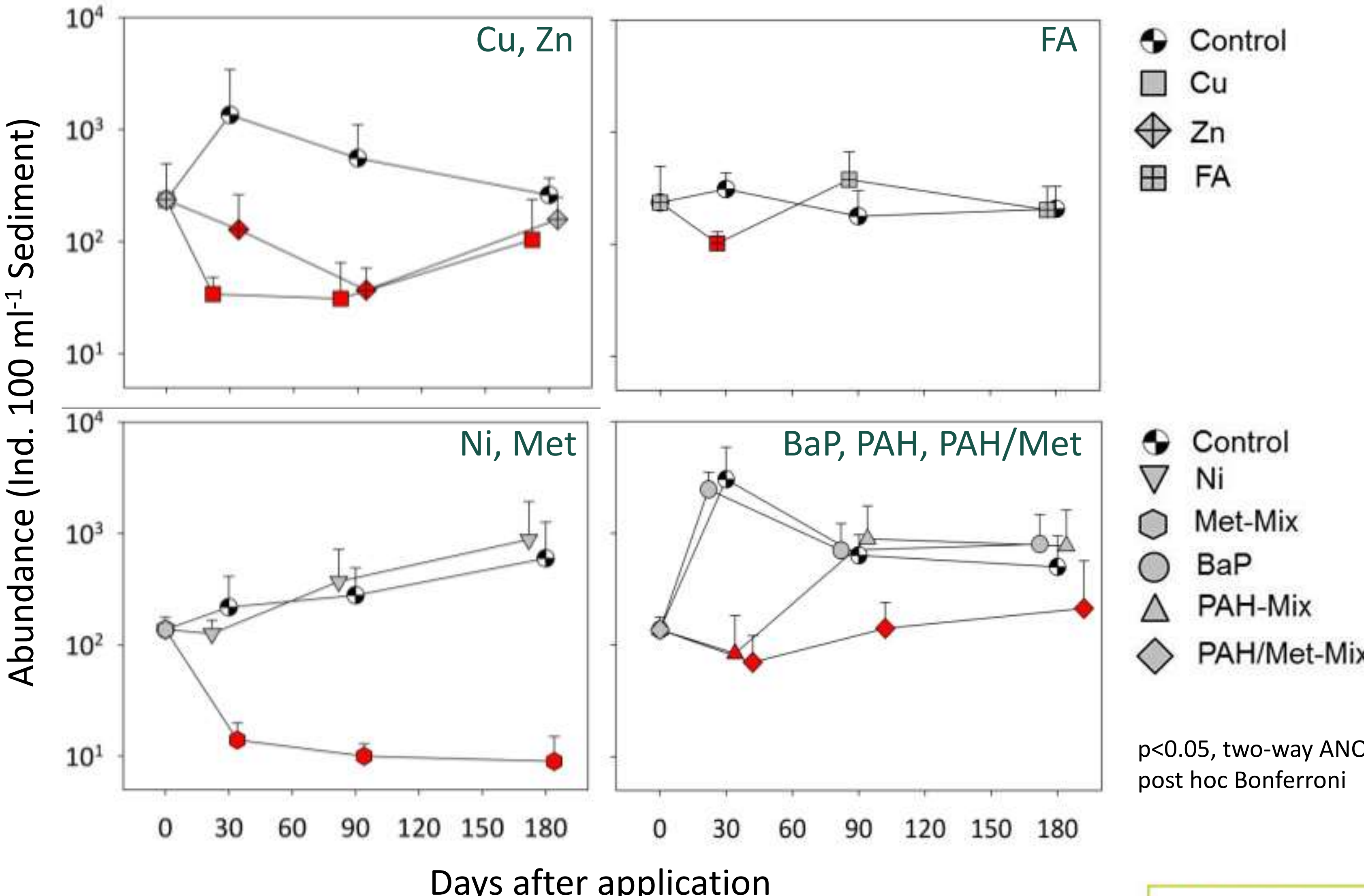
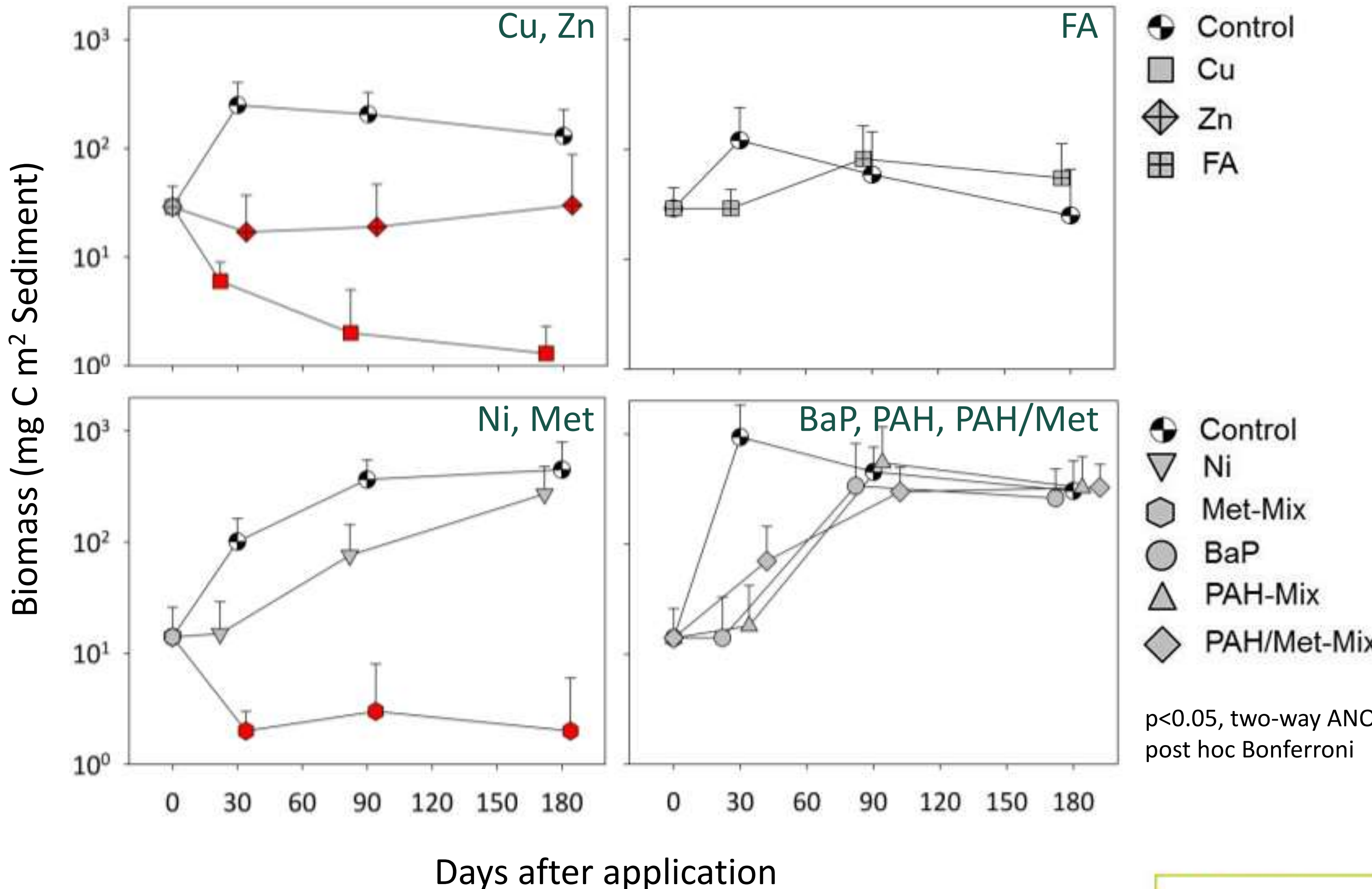
# Abundance meiofauna (mean + sd)



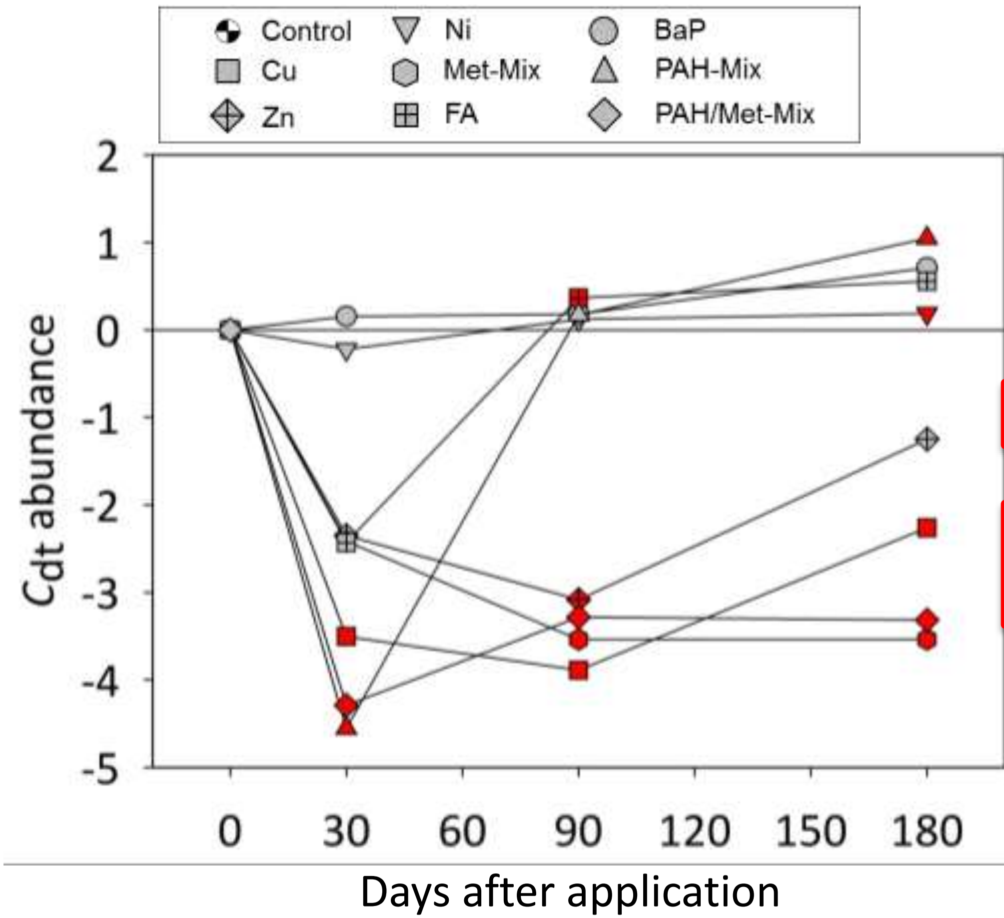

p<0.05, two-way ANOVA, post hoc Bonferroni

# Biomass meiofauna (mean + sd)




$p<0.05$, two-way ANOVA, post hoc Bonferroni

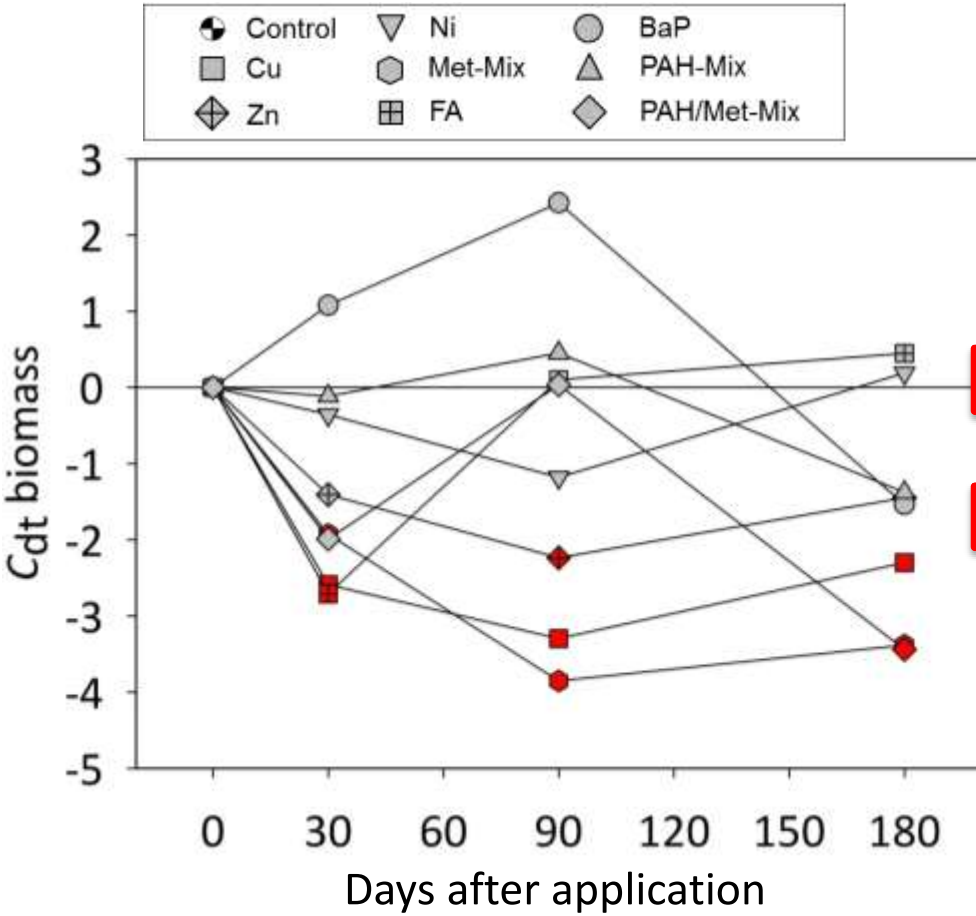
# Taxa composition-abundance (mean + sd)




| Taxa | Cu, Zn | FA | Ni, Met | BaP, PAH, PAH/Met |
|---|---|---|---|---|
| Gastrotrichs | 0.00 | 0.00 | 0.27 | 0.30 |
| Cladocerans | 0.22 | 0.63 | 0.10 | 0.02 |
| Oligochaetes | 0.72 | 0.09 | 0.63 | -0.01 |
| Tardigrades | 0.38 | 0.38 | 0.38 | 0.34 |
| Nematodes | 0.58 | 0.24 | 0.62 | 0.54 |
| Rotifers | 0.68 | 0.48 | 0.84 | 0.53 |

$p<0.05$, Monte-Carlo permutation test

# Taxa composition-biomass (mean + sd)




| Taxa | Cu, Zn | FA | Ni, Met | BaP, PAH, PAH/Met |
|---|---|---|---|---|
| Gastrotrichs | 0.00 | 0.00 | 0.16 | -0.08 |
| Tardigrades | 0.35 | 0.22 | 0.30 | 0.07 |
| Oligochaetes | 0.75 | -0.05 | 0.63 | -0.37 |
| Rotifers | 0.39 | 0.32 | 0.16 | 0.10 |
| Cladocerans | 0.17 | 0.65 | 0.14 | 0.08 |
| Nematodes | 0.66 | 0.30 | 0.60 | -0.07 |

$p<0.05$, Monte-Carlo permutation test


→ **Meiofauna sensitive to chemical stress**

→ **Community composition most susceptible**

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# Ranking of the various analysed meiofauna taxa

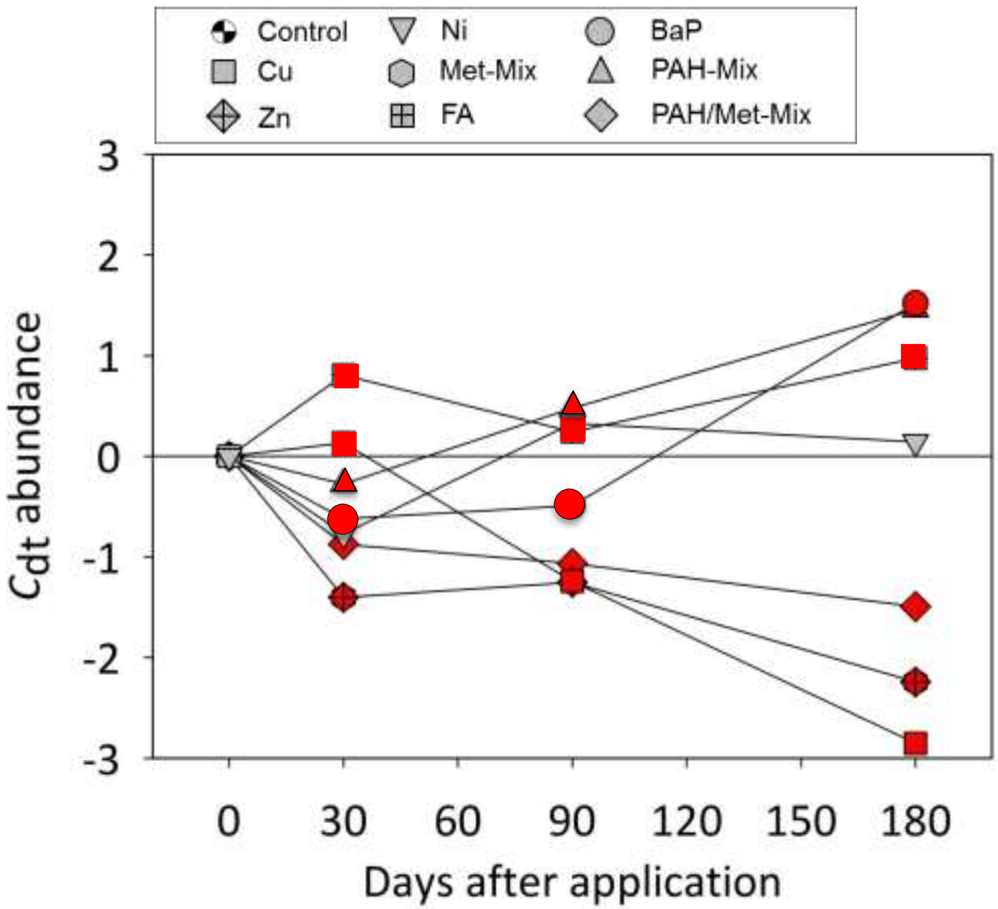
| Abundance | | | Biomass | | |
|---|---|---|---|---|---|
| **metal** | **organic** | **total** | **metal** | **organic** | **total** |
| Cladocerans | Cladocerans | Cladocerans | Cladocerans | Gastrotriches | Gastrotriches |
| Gastrotriches | Gastrotriches | Gastrotriches | Gastrotriches | Tardigrades | Cladocerans |
| Tardigrades | Oligochaetes | Tardigrades | Rotifers | Cladocerans | Tardigrades |
| Nematodes | Tardigrades | Oligochaetes | Tardigrades | Rotifers | Rotifers |
| Oligochaetes | Nematodes | Nematodes | Nematodes | Oligochaetes | Oligochaetes |
| Rotifers | Rotifers | Rotifers | Oligochaetes | Nematodes | Nematodes |

tolerant

sensitive

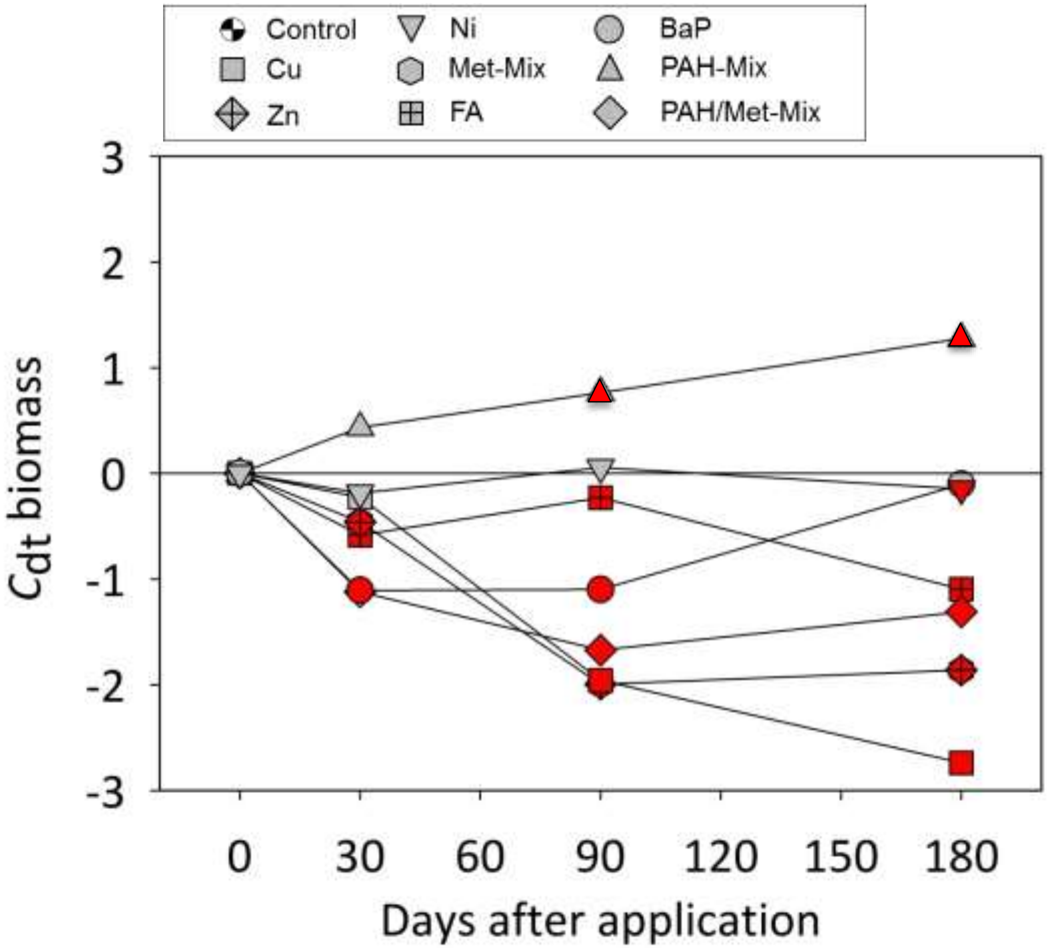
- → **Effects of spiked sediments highly taxon-specific**
- → **Oligochaetes, Rotifers & Nematodes most affected**
- → **Sensitivity widely independent of the applied compounds**
- → **Nematodes most abundant in contaminated sediments**

# Species composition-abundance (mean + sd)




| Species | Cu, Zn | FA | Ni, Met | BaP, PAH, PAH/Met |
|---|---|---|---|---|
| *E. vulgaris* | 0.31 | 0.51 | 0.61 | 0.32 |
| *E. longicaudatula* | 0.29 | 0.48 | 0.58 | 0.32 |
| *E. barbata* | 0.26 | 0.42 | 0.41 | 0.31 |
| *E. pseudobulbosa* | 0.21 | 0.33 | 0.30 | 0.29 |
| | | | | |
| *A. terricola* | -0.17 | -0.31 | -0.21 | -0.24 |
| *M. paramacrura* | -0.20 | -0.37 | -0.28 | -0.26 |
| *I. macramphis* | -0.34 | -0.45 | -0.28 | -0.26 |
| *T. setifera* | -0.49 | -0.64 | -0.62 | -0.51 |

# Species composition-biomass (mean + sd)




| Species | Cu, Zn | FA | Ni, Met | BaP, PAH, PAH/Met |
|---|---|---|---|---|
| *I. macramphis* | 0.46 | 0.74 | 0.47 | 0.47 |
| *E. longicaudatula* | 0.30 | 0.35 | 0.42 | 0.24 |
| *E. vulgaris* | 0.30 | 0.28 | 0.42 | 0.23 |
| *A. terricola* | 0.26 | 0.18 | 0.40 | 0.17 |
| | | | | |
| *M. paramacrura* | -0.25 | -0.44 | -0.10 | -0.17 |
| *P. cf pellioides* | -0.26 | -0.50 | -0.20 | -0.19 |
| *I. macramphis* | -0.26 | -0.52 | -0.20 | -0.21 |
| *T. setifera* | -0.55 | -0.60 | -0.69 | -0.45 |


→ **Nematodes among the most sensitive taxa**

→ **Species composition most susceptible**

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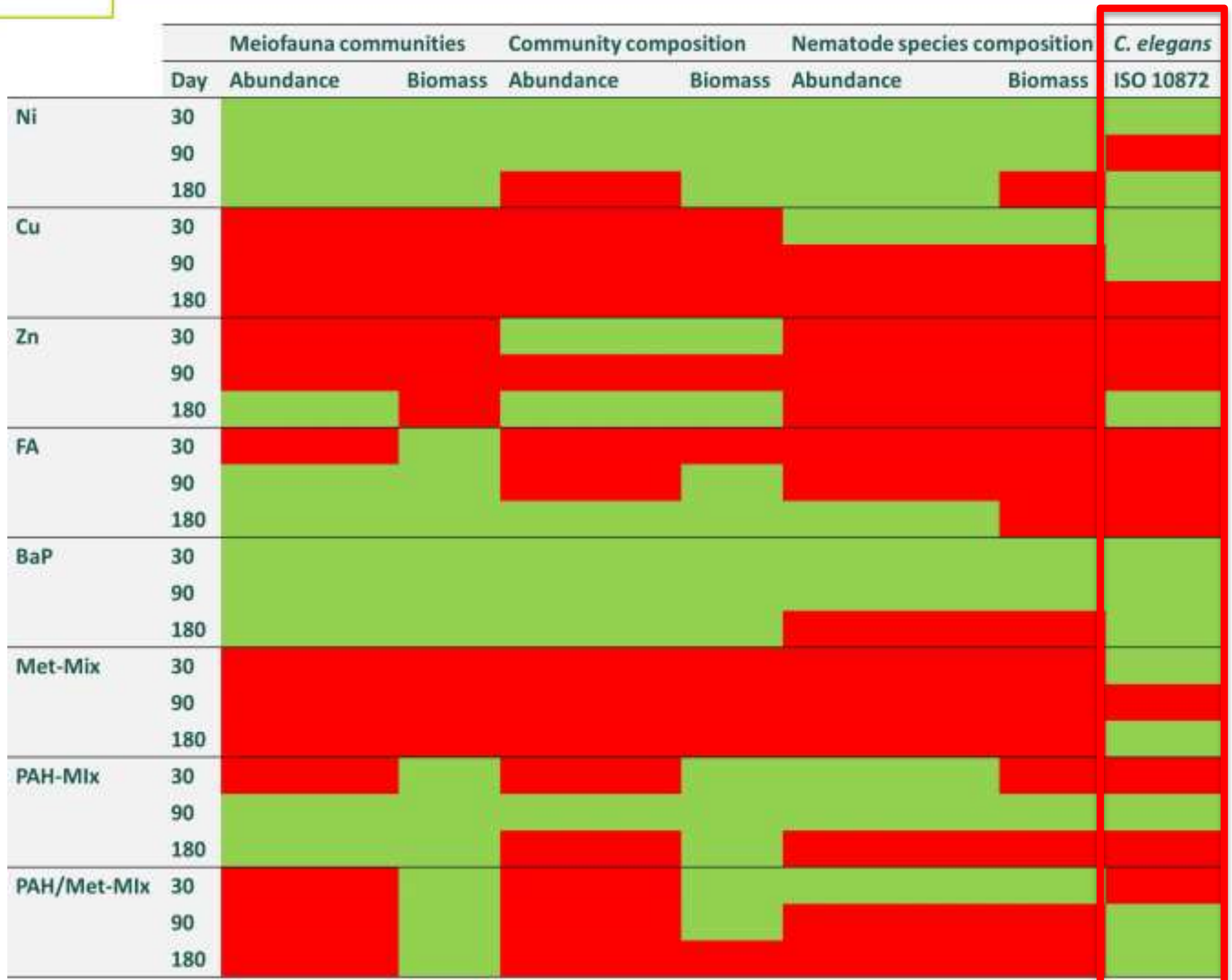
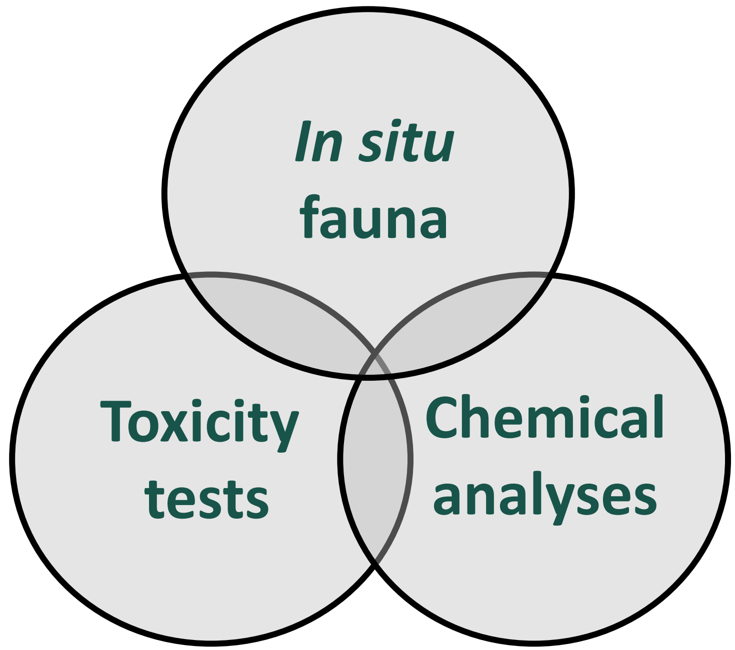



→ **Toxicity tests on *C. elegans* comparatively sensitive**

→ **Representative of meiofaunal sensitivity**

# Risk assessment of soft sediments (SQT)



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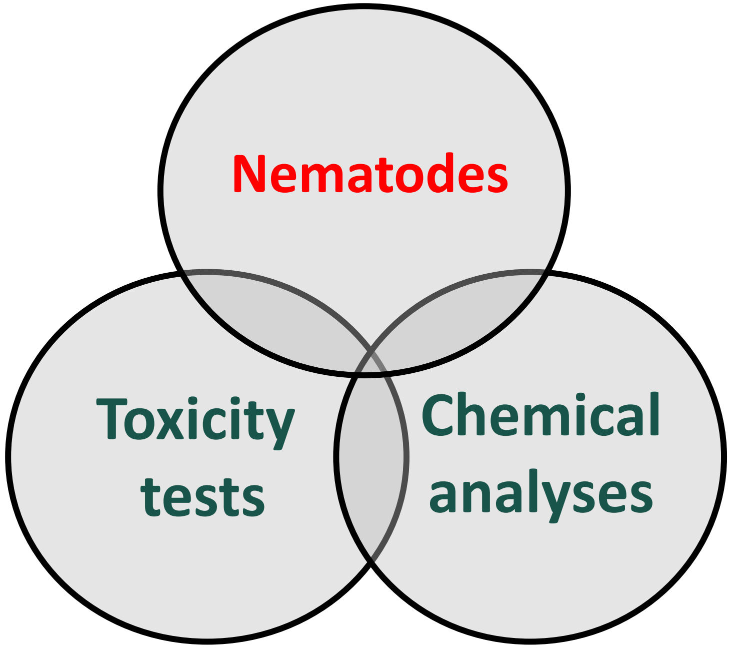
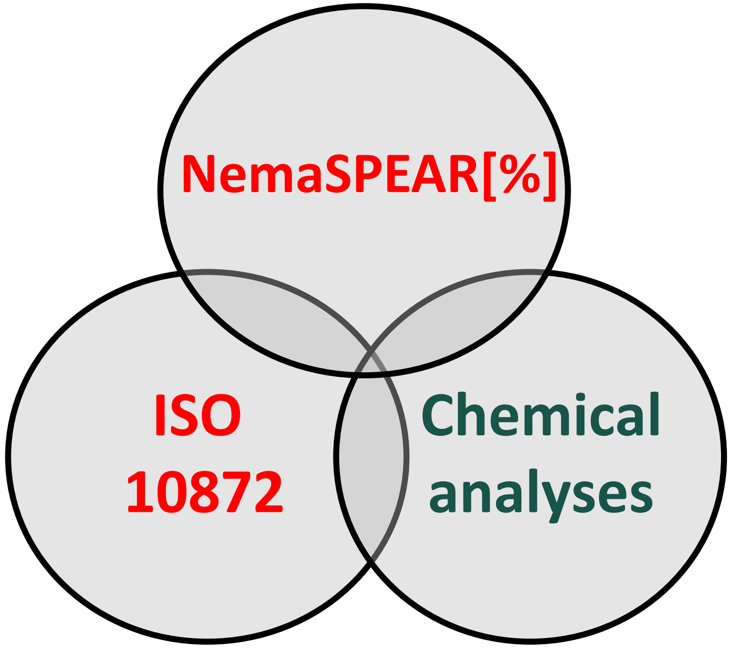



→ Nematodes capable to represent meiofaunal communities

→ Bioindication based on nematodes recommended (NemaSPEAR[%]-index)

# Risk assessment of soft sediments (SQT)




→ Nematodes capable to represent meiofaunal communities

→ Bioindication based on nematodes recommended (NemaSPEAR[%]-index)

→ Toxicity test with *C. elegans* (ISO 10872) suitable bioassay

# Many thanks to the involved cooperation partners

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ecological
sediment &
soil
assessment

| Parameter | Content/concentration |
|---|---|
| % water content | 18.2 |
| % gravel[a] | 2.1 |
| % sand | 96.1 |
| % fines (silt and clay) | 1.5 |
| % TOC | 0.3 |
| As (mg/kg) | < 1 |
| Cd (mg/kg) | < 0.1 |
| Cr (mg/kg) | < 2 |
| Cu (mg/kg) | < 2 |
| Hg (mg/kg) | < 0.05 |
| Ni (mg/kg) | < 2 |
| Pb (mg/kg) | < 5 |
| Zn (mg/kg) | < 10 |
| ∑ PAHs (mg/kg)[b] | < 0.2 |
| ∑ PCBs (µg/kg)[c] | < 0.2 |
| ∑ HCHs (µg/kg)[d] | < 0.1 |
| ∑ DDTs (µg/kg)[e] | < 0.3 |
| HCB (µg/kg) | < 0.05 |

[a] Sediment fraction 2-63 mm
[b] 16 PAHs (EPA 610)
[c] 7 PCBs: 28, 52, 101, 11, 138, 153, 180
[d] α-, β-, γ-HCH
[e] o,p'-DDT, -DDD, -DDE

→ **Höss et al. (2011) analysed**

**> 200 sediment samples**

→ **Correlation of specific species with toxic potential of sediments**

→ **Identification of NemaSPEAR (Nematode SPEcies At Risk)**

→ **NemaSPEAR[%]-index**

| | | Electrical conductivity (µS/cm) | | | Temperature (°C) | | | $O_2$ (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Day | C | LC | HC | C | LC | HC | C | LC | HC | C | LC | HC |
| Ni | 30 | 100.2 ± 5.1 | 102.7 ± 4.0 | 106.7 ± 5.8 | 20.7 ± 0.5 | 20.9 ± 0.4 | 20.8 ± 0.3 | 8.6 ± 0.1 | 8.5 ± 0.2 | 8.0 ± 0.6 | 6.5 ± 1.3 | 7.3 ± 0.0 | 7.1 ± 0.0 |
| | 90 | 118.2 ± 8.6 | 109.5 ± 12.8 | 97.3 ± 8.0 | 20.6 ± 0.2 | 20.9 ± 0.5 | 21.3 ± 0.2 | 8.5 ± 0.3 | 8.3 ± 0.2 | 8.5 ± 0.2 | 7.3 ± 0.5 | 7.5 ± 0.0 | 7.6 ± 0.1 |
| | 180 | 103.5 ± 8.6 | 105.0 ± 11.2 | 112.3 ± 14.1 | 21.1 ± 0.2 | 21.1 ± 0.4 | 20.2 ± 0.6 | 7.6 ± 0.3 | 7.4 ± 0.4 | 7.7 ± 0.4 | 7.5 ± 0.5 | 7.7 ± 0.4 | 7.5 ± 0.4 |
| Cu | 30 | 210.0 ± 19.2 | 207.6 ± 18.2 | 343.4 ± 15.8* | 20.0 ± 0.3 | 20.1 ± 0.3 | 19.9 ± 0.3 | 6.8 ± 0.5 | 6.7 ± 0.6 | 6.6 ± 0.3 | 8.0 ± 0.1 | 8.1 ± 0.0 | 7.7 ± 0.0* |
| | 90 | 184.6 ± 11.9 | 212.6 ± 6.0 | 323.2 ± 16.1* | 20.0 ± 0.3 | 20.1 ± 0.3 | 19.9 ± 0.3 | 6.1 ± 0.2 | 5.8 ± 0.2 | 6.0 ± 0.2 | 7.7 ± 0.4 | 8.1 ± 0.0 | 7.8 ± 0.1 |
| | 180 | 196.6 ± 46.1 | 215.8 ± 34.7 | 363.6 ± 72.8* | 22.3 ± 0.1 | 22.4 ± 0.1 | 22.5 ± 0.1 | 5.8 ± 0.4 | 5.7 ± 0.6 | 5.5 ± 0.4 | 7.6 ± 0.1 | 7.9 ± 0.1 | 7.9 ± 0.2 |
| Zn | 30 | 194.0 ± 5.3 | 211.8 ± 45.0 | 279.0 ± 15.4* | 20.1 ± 0.4 | 20.1 ± 0.1 | 20.8 ± 0.2 | 7.2 ± 0.6 | 6.8 ± 0.5 | 6.7 ± 0.4 | 7.9 ± 0.1 | 7.9 ± 0.2 | 7.5 ± 0.1* |
| | 90 | 195.2 ± 14.8 | 203.8 ± 28.7 | 256.3 ± 10.3* | 20.1 ± 0.4 | 20.1 ± 0.1 | 20.8 ± 0.2 | 6.0 ± 0.2 | 5.6 ± 0.6 | 6.1 ± 0.1 | 8.1 ± 0.0 | 8.0 ± 0.1 | 7.7 ± 0.1* |
| | 180 | 164.6 ± 7.5 | 196.6 ± 58.6 | 206.8 ± 33.4 | 22.4 ± 0.1 | 22.5 ± 0.2 | 22.7 ± 0.1 | 5.6 ± 0.3 | 5.3 ± 0.4 | 5.4 ± 0.3 | 8.0 ± 0.1 | 7.9 ± 0.1 | 7.9 ± 0.1 |
| FA | 30 | 174.6 ± 6.1 | 176.6 ± 14.3 | 171.0 ± 9.9 | 20.0 ± 0.5 | 19.9 ± 0.5 | 19.9 ± 0.6 | 7.1 ± 0.4 | 6.8 ± 0.3 | 7.0 ± 0.4 | 7.8 ± 0.1 | 7.9 ± 0.1 | 7.9 ± 0.1 |
| | 90 | 187.2 ± 11.5 | 175.2 ± 9.2 | 181.4 ± 8.8 | 20.0 ± 0.5 | 19.9 ± 0.5 | 19.9 ± 0.6 | 6.0 ± 0.1 | 5.7 ± 0.4 | 5.9 ± 0.3 | 8.2 ± 0.1 | 8.2 ± 0.0 | 8.2 ± 0.0 |
| | 180 | 224.8 ± 122.6 | 158.6 ± 3.8 | 162.0 ± 32.6 | 21.8 ± 0.4 | 22.1 ± 0.4 | 22.2 ± 0.2 | 5.8 ± 0.5 | 5.6 ± 0.1 | 5.6 ± 0.2 | 8.1 ± 0.1 | 8.0 ± 0.1 | 7.9 ± 0.0 |
| B(a)P | 30 | 101.8 ± 5.3 | 104.2 ± 5.9 | 99.8 ± 3.4 | 20.1 ± 0.3 | 20.3 ± 0.7 | 19.7 ± 0.4 | 8.4 ± 0.2 | 8.1 ± 0.4 | 8.4 ± 0.1 | 7.2 ± 0.1 | 7.3 ± 0.1 | 7.4 ± 0.1 |
| | 90 | 99.7 ± 9.2 | 100.5 ± 12.3 | 89.0 ± 37.7 | 20.7 ± 1.0 | 19.7 ± 0.7 | 20.8 ± 0.7 | 8.5 ± 0.3 | 8.4 ± 0.4 | 8.1 ± 0.6 | 7.9 ± 0.4 | 7.9 ± 0.2 | 7.9 ± 0.2 |
| | 180 | 112.7 ± 9.2 | 114.5 ± 20.8 | 117.2 ± 10.8 | 20.2 ± 1.0 | 20.9 ± 0.4 | 20.8 ± 0.3 | 7.6 ± 0.3 | 7.6 ± 0.2 | 7.2 ± 0.4 | 7.3 ± 0.4 | 7.1 ± 0.4 | 7.3 ± 0.1 |
| Met-Mix | 30 | 107.5 ± 4.5 | 133.5 ± 20.1 | 324.8 ± 19.7* | 21.0 ± 0.3 | 20.9 ± 0.3 | 21.3 ± 0.1 | 8.3 ± 0.2 | 8.0 ± 0.7 | 8.4 ± 0.1 | 7.0 ± 0.9 | 7.1 ± 0.1 | 6.1 ± 0.1* |
| | 90 | 106.0 ± 14.8 | 118.5 ± 3.6 | 347.2 ± 37.0* | 20.4 ± 0.4 | 20.9 ± 0.4 | 21.8 ± 0.1 | 8.2 ± 0.4 | 8.1 ± 0.5 | 7.8 ± 0.6 | 7.7 ± 0.2 | 7.5 ± 0.0 | 5.2 ± 0.6* |
| | 180 | 110.3 ± 14.8 | 152.3 ± 34.0 | 361.3 ± 47.9 | 20.6 ± 0.4 | 20.8 ± 0.6 | 21.4 ± 0.5 | 7.7 ± 0.4 | 7.6 ± 0.4 | 7.8 ± 0.4 | 7.5 ± 0.2 | 7.4 ± 0.4 | 6.3 ± 0.4* |
| PAH-Mix | 30 | 153.2 ± 21.5 | 141.3 ± 25.7 | 138.0 ± 15.8 | 21.0 ± 0.3 | 20.0 ± 0.5 | 20.3 ± 0.2 | 7.8 ± 0.6 | 8.4 ± 0.2 | 7.2 ± 1.4 | 6.8 ± 0.5 | 7.4 ± 0.1 | 5.2 ± 0.2 |
| | 90 | 123.2 ± 11.7 | 110.8 ± 11.9 | 113.2 ± 13.0 | 20.7 ± 0.5 | 20.6 ± 0.4 | 20.8 ± 0.3 | 8.0 ± 0.2 | 7.6 ± 1.0 | 8.1 ± 0.3 | 7.9 ± 0.3 | 7.2 ± 0.2 | 7.5 ± 0.1 |

| | Ni | Cu | Zn | FA | BaP | Met-Mix | | | | | PAH-Mix | | | | | PAH/Met-Mix | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Ni | Cu | Zn | Pb | Cd | BaP | FA | Chr | Phe | Pyr | Ni | Cu | Zn | Pb | Cd | BaP | FA | Chr | Phe | Pyr |
| Nominal Conc. | 3.0 | 100.0 | 100.0 | 20.0 | 10.0 | 5.92 | 12.63 | 105.74 | 15.08 | 0.62 | 1.24 | 3.30 | 0.87 | 2.20 | 2.40 | 2.98 | 6.31 | 52.87 | 7.54 | 0.31 | 0.62 | 1.66 | 0.48 | 1.08 | 1.20 |