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bfg Bundesanstalt für Gewässerkunde

ecossa
ecological
sediment &
soil
assessment

Nematode-related criteria for sediment quality assessment

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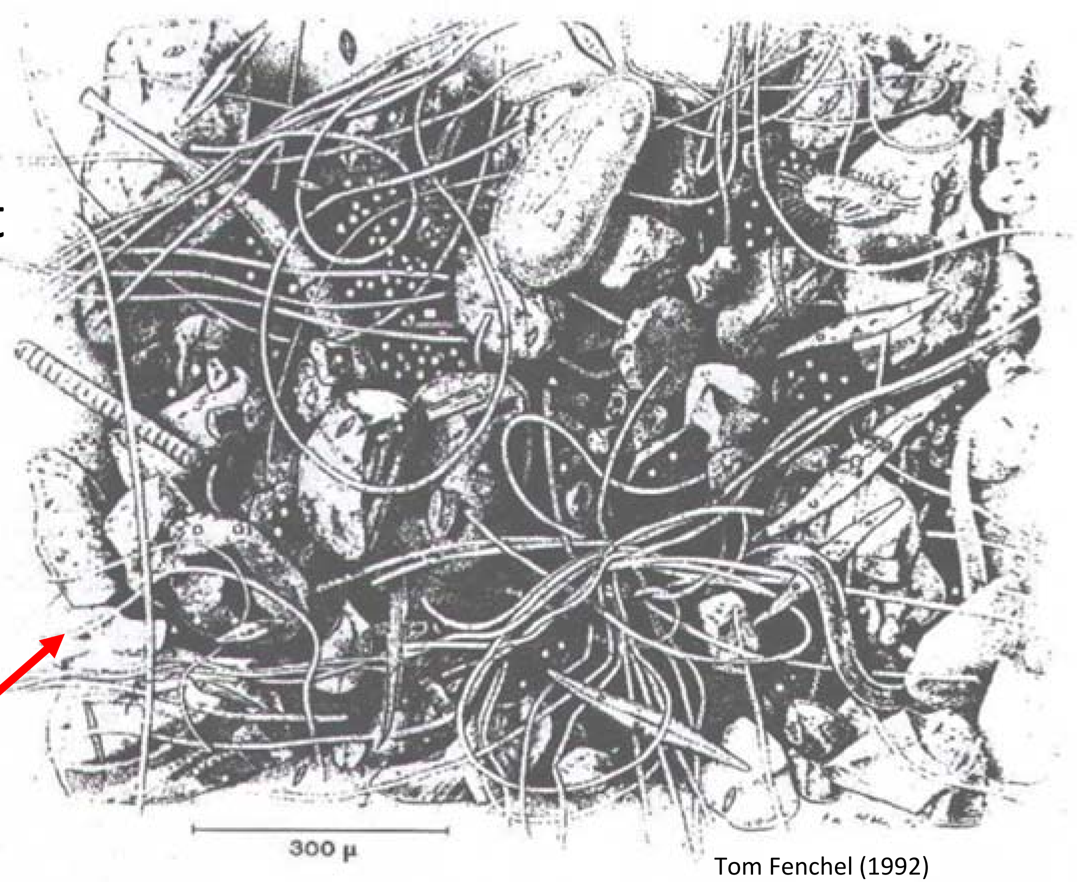
Exclusively endobenthic organisms

- Organisms usually used for Sediment Quality Assessment: Macrobenthos
- However, few macrobenthic taxa exclusively/strictly endobenthic
    - moreover, those taxa often not dominant in sediments
    - ... especially in fine sediments, which are often hot spots of contamination
- Large part of benthic community is so far rather neglected: Meiobenthos!
    - mainly exclusively endobenthic!



Tom Fenchel (1992)

Meiobenthos regarded / protected by current Sediment Quality Assesments (SQAs) or Sediment Quality Guidelines (SQGs)?

Meiobenthos / Meiofauna

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Smaller than snails and mussels ... → Macrobenthos

Meiobenthos

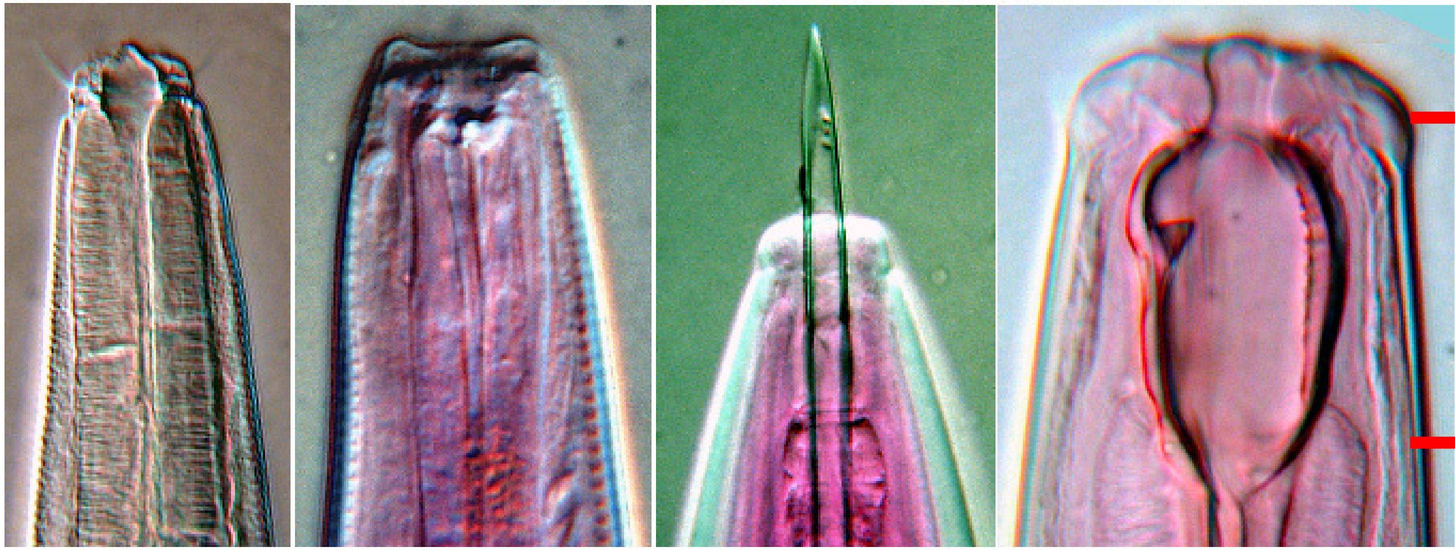
... bigger than bacteria and protozoans → Microbenthos

Photos: FiftIMCo, University of Bielefeld, Senckenberg, and Getty images

Nematodes

- Abundance: up to over 1 million individuals per m^2 (up to 90% of the meiobenthic community)
- Diversity: up to over 100 species in one habitat
- Various feeding types, such as:

bacteria and algae feeder | suction feeder | predators/omnivors

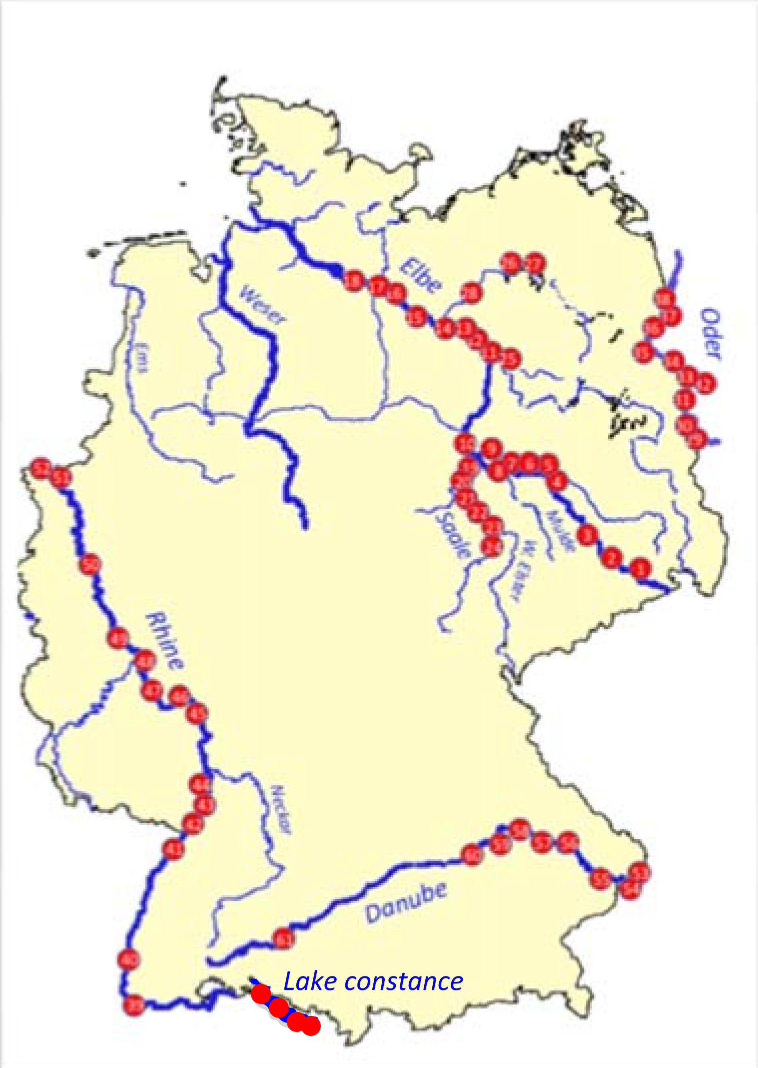


→ functional/trait diversity

→ different exposure pathways

- **Dominant in fine sediments!**

Development of SQGs with nematodes?



Years 2000 to 2008:
203 samplings at 103 sites (3-5 replicates each)

- about 30,000 nematodes (297 species) identified
- TOC, particle size distribution
- chemical analysis

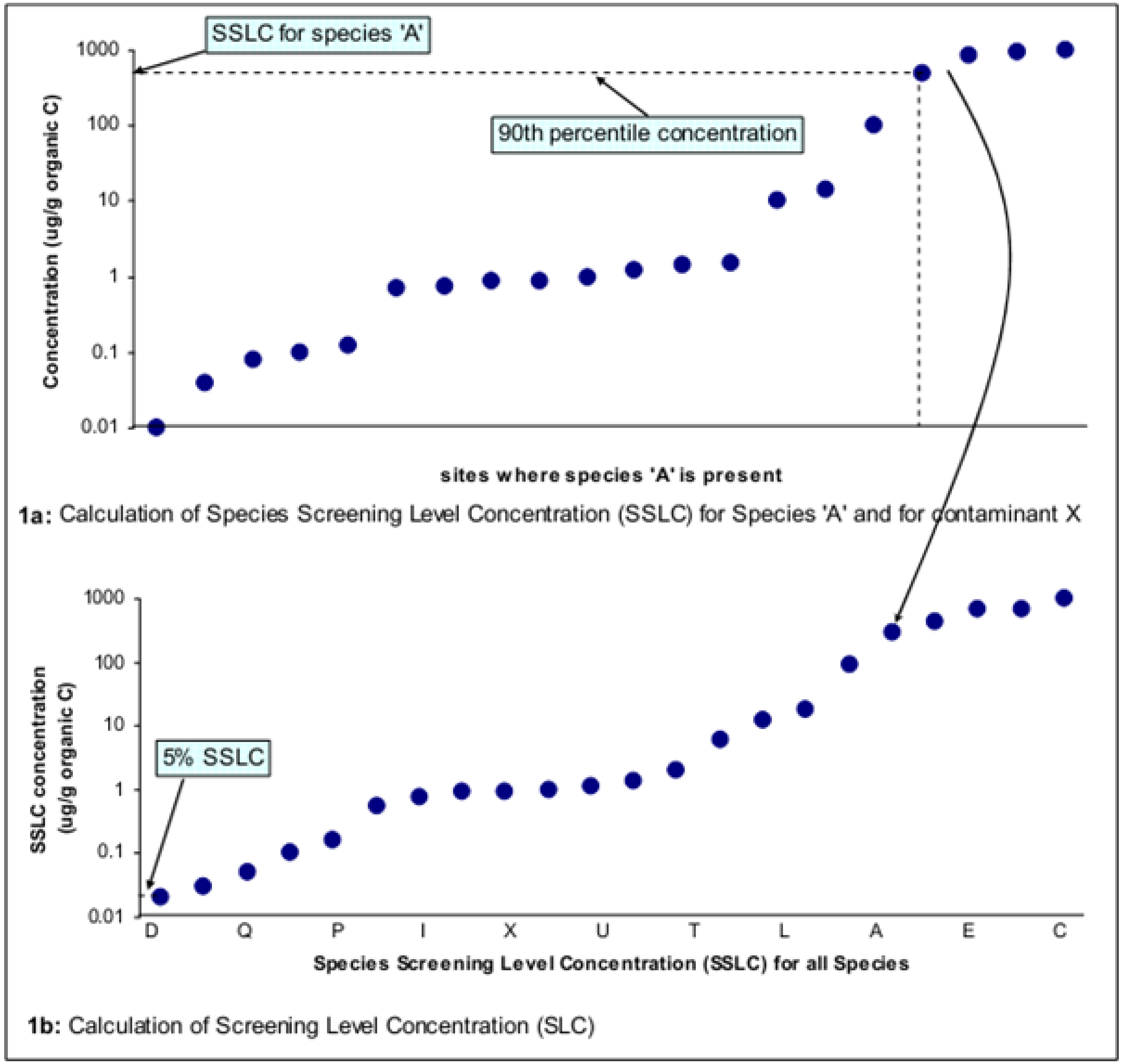
Preliminary dataset* that is currently extended
(*described in Höss et al., 2011: Environ Int 37: 940-949)

Co-occurence approaches for deriving
Sediment Quality Guidelines (SQGs)
(matching chemistry and effects data):

- Screening Level Concentration Approach (SLCA)
- Logistic Regression Modelling Approach (LRMA)

Screening level concentration approach (SLCA)

e.g., Neff et al. (1986), Report prepared for US EPA



adopted from Fletcher et al. (2008), Ontario Ministry of the Environment, Canada

Threshold effect concentration (TEC):

„Concentration below which adverse effects on benthic invertebrates are unlikely to be observed“

TEC: Lowest Effect Level (LEL) = SLC at 5% SSLC

Probable effect concentration (PEC):

„Concentration above which harmful effects on benthic invertebrates are likely to be observed“

PEC: Probable Effect Level (PEL) = SLC at 95% SSLC

Nematode-based TECs (SLCA)

	SLCA	SLCA	Consensus-based
Substance(s)	N-TEC	TEC de Deckere*	TEC MacDonald**
Cadmium	0.6	0.7	0.99
Lead	23	19	36
Mercury	0.2	0.3	0.2
Nickel	45	15	23
Zinc	98	129	121
Benzo(a)pyrene	0.15	0.16	0.15
Fluoranthene	0.5	0.21	0.42
p,p-DDD	0.06	0.01	4.88
p,p-DDE	0.36	0.39	3.16
Sum PCBs (7)	3.98	3.99[#]	-

* de Deckere et al. (2011), J Soils Sediments 11:504-517

** MacDonald et al. (2000), Arch Environ Contam Toxicol 39:20-31

[#] estimated

mg/kg dw (except Sum PCBs: µg/kg dw)

Nematode-based PECs (SLCA)

	SLCA	SLCA	Consensus-based
Substance(s)	**N-PEC**	**PEC de Deckere***	**PEC MacDonald****
Cadmium	15	13	5
Lead	314	167	128
Mercury	18	2	1
Nickel	100	44	49
Zinc	1884	1300	459
Benzo(a)pyrene	0.91	0.81	1.45
Fluoranthene	2.37	1.6	2.23
p,p-DDD	265	5	28
p,p-DDE	61	11	31
Sum PCBs (7)	167	60#	-

* de Deckere et al. (2011), J Soils Sediments 11:504-517

** MacDonald et al. (2000), Arch Environ Contam Toxicol 39:20-31

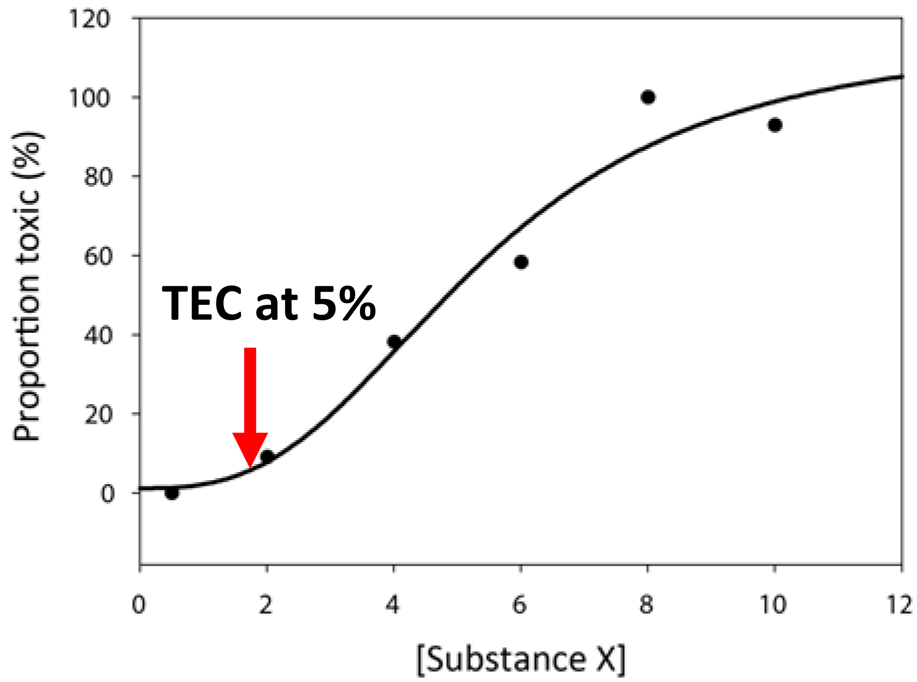
estimated

mg/kg dw (except Sum PCBs: µg/kg dw)

Logistic regression modelling approach (LRMA)

e.g., Field et al. (2002), Environ Toxicol Chem 21: 1993-2005

Calculation of the proportion of toxic samples within concentration intervals and fitting a logistic regression



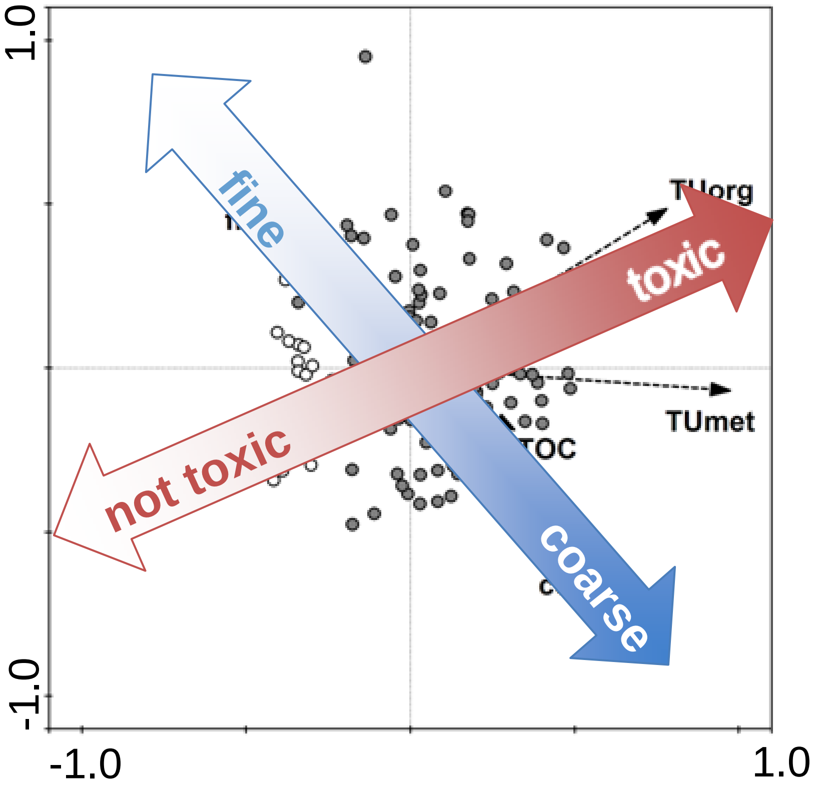
However, classification of toxic samples was done by using a community-based toxicity index, the NemaSPEAR[%]*:

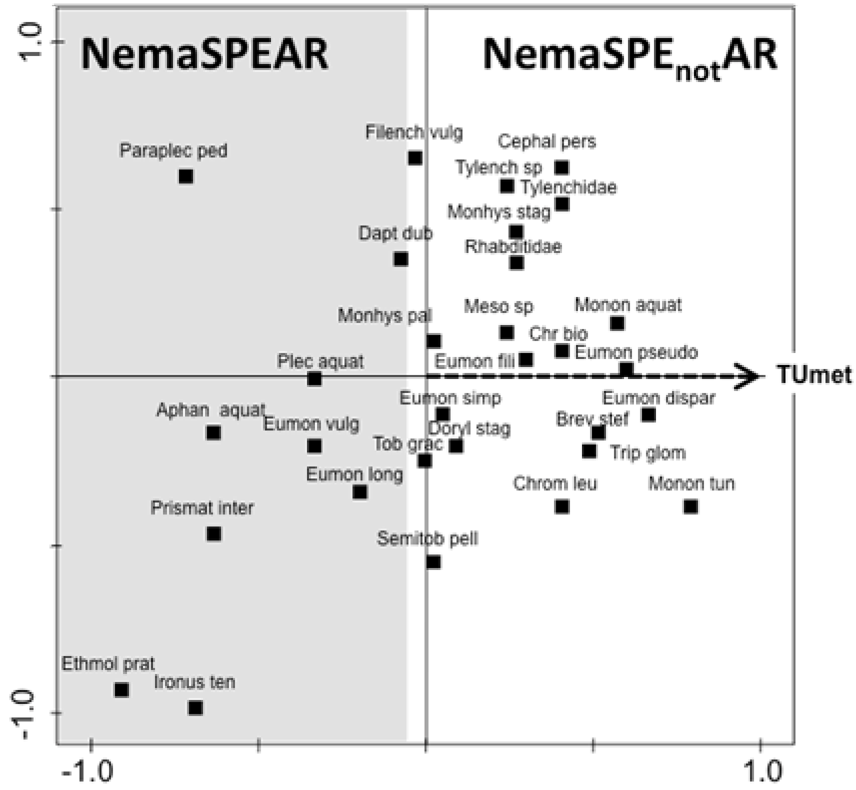
Samples are designated as toxic if NemaSPEAR[%] < 30

*Höss et al. (2011), Environ Int 37: 940-949 bfg Bundesanstalt für Gewässerkunde

The NemaSPEAR[%] index

(Höss et al., 2011: Environ Int 37: 940-949)





Calculation of the indices for metals ($NemaSPEAR[\%]_{metal}$) and organic chemicals ($NemaSPEAR[\%]_{organic}$):

$$NemaSPEAR[\%]_{metal/organic} = \frac{\sum \log[SPEAR]_{abundance}}{\sum \log[SPEAR+SPE_{not}AR]_{abundance}} \times 100$$

LRMA using the NemaSPEAR as toxicity indicator

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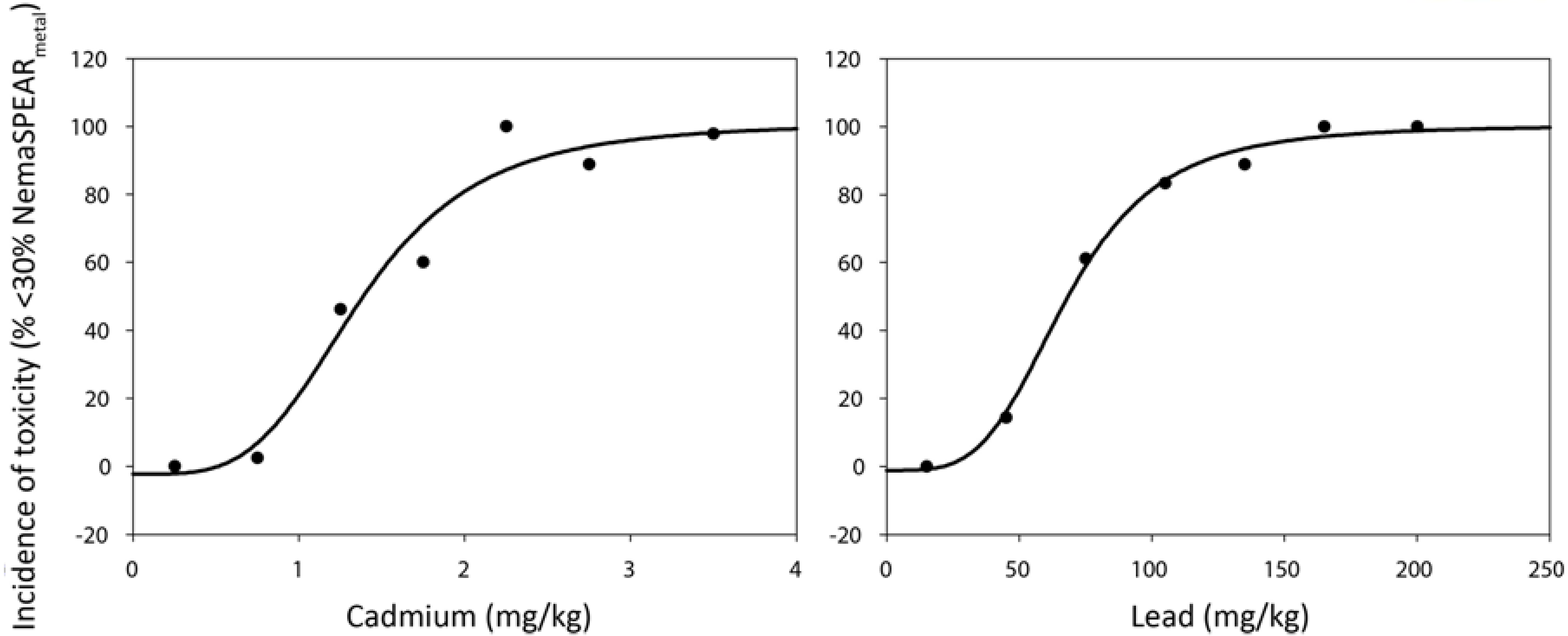


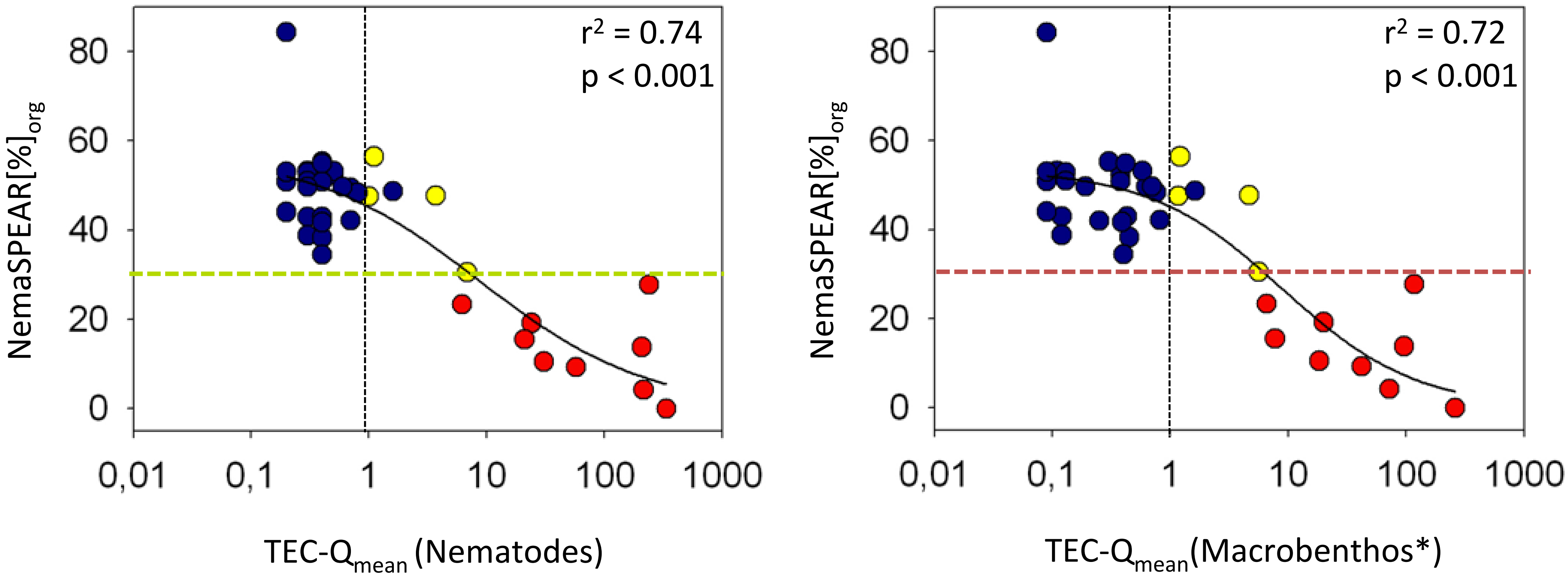
	SLCA	LRMA	SLCA	Consensus-based
Substance(s)	**N-TEC**	**N-TEC (5%)**	**TEC de Deckere***	**TEC MacDonald****
Cadmium	0.6	0.7	0.7	0.99
Lead	23	33	19	36

mg/kg dw

* de Deckere et al. (2011), J Soils Sediments 11:504-517

** MacDonald et al. (2000), Arch Environ Contam Toxicol 39:20-31

WoE – NemaSPEAR and SQGs as two LoE?



* de Deckere et al. (2011), J Soils Sediments 11:504-517

Conclusion

- SQGs can be derived based on nematode communities
- To this point of the present study ...
  - Nematode-based TECs seem to indicate threshold concentrations valid for the „whole“ benthic community, including macrobenthic invertebrates
  - Nematode-based PECs, however, seem to be higher than those based on macrobenthic invertebrates and thus, ...
    - explicit effects in macroinvertebrate communities might occur already at lower concentrations
    - within nematode communities a broad spectrum of sensitive and tolerant species exists, which is valuable for sediment quality assessments (prioritization, classification)

Conclusion

- More attention should be paid to meiobenthic organisms, such as nematodes, for sediment quality assessment
  - From an ecological point of view evident (dominant organisms, complex food web), but mainly practical reasons (small, identification) constrained their consideration
  - From an ecotoxicological point of view their broad sensitivity spectrum and their high abundance and diversity in (fine) sediments valuable (NemaSPEAR[%])
  - Especially in freshwater sediments meiofauna rather neglected
- However, nematodes (and other meiofauna) should not generally replace assessments with macroinvertebrates! **They are a meaningful complement for a comprehensive sediment quality assessment!**

Covering many feeding types, traits, functions, and exposure pathways as exclusively endobenthic organisms!

Outlook

- Further refinements and valdiations of SQG calculations

- Addressing general SQG-related questions (in a case study):
  - Use of these and other SQGs for screening in German waterways?
  - Use of mean SQG-Quotients for sediment/dredged material quality classfication and prioritization?
  - Does normalization (e.g., to OC) increase predictability of toxicity?

- NemaSPEAR[%] validation and refinement project:
  University Bielefeld, ECOSSA, and BfG

- DNA barcode-based community analysis increases applicability of nematodes
  - Wageningen UR (Dr Hans Helder)
  - University Bielefeld (Dr Kai Ristau)

Are we adequately assessing an ecosystems health by only looking at the big ones?

Thank you for your attention!