

7<sup>th</sup> International SedNet conference on 6-9 April 2011, Venice, Italy

Sediments and Biodiversity: bridging the gap between science and policy

# Remobilization of particle-bound contaminants from re-suspended sediments and their impact on aquatic organisms

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Promoted by:



# Outline

- Motivation
- Methods
- Material
- Test program and Results
- Summary and Outlook



# Motivation



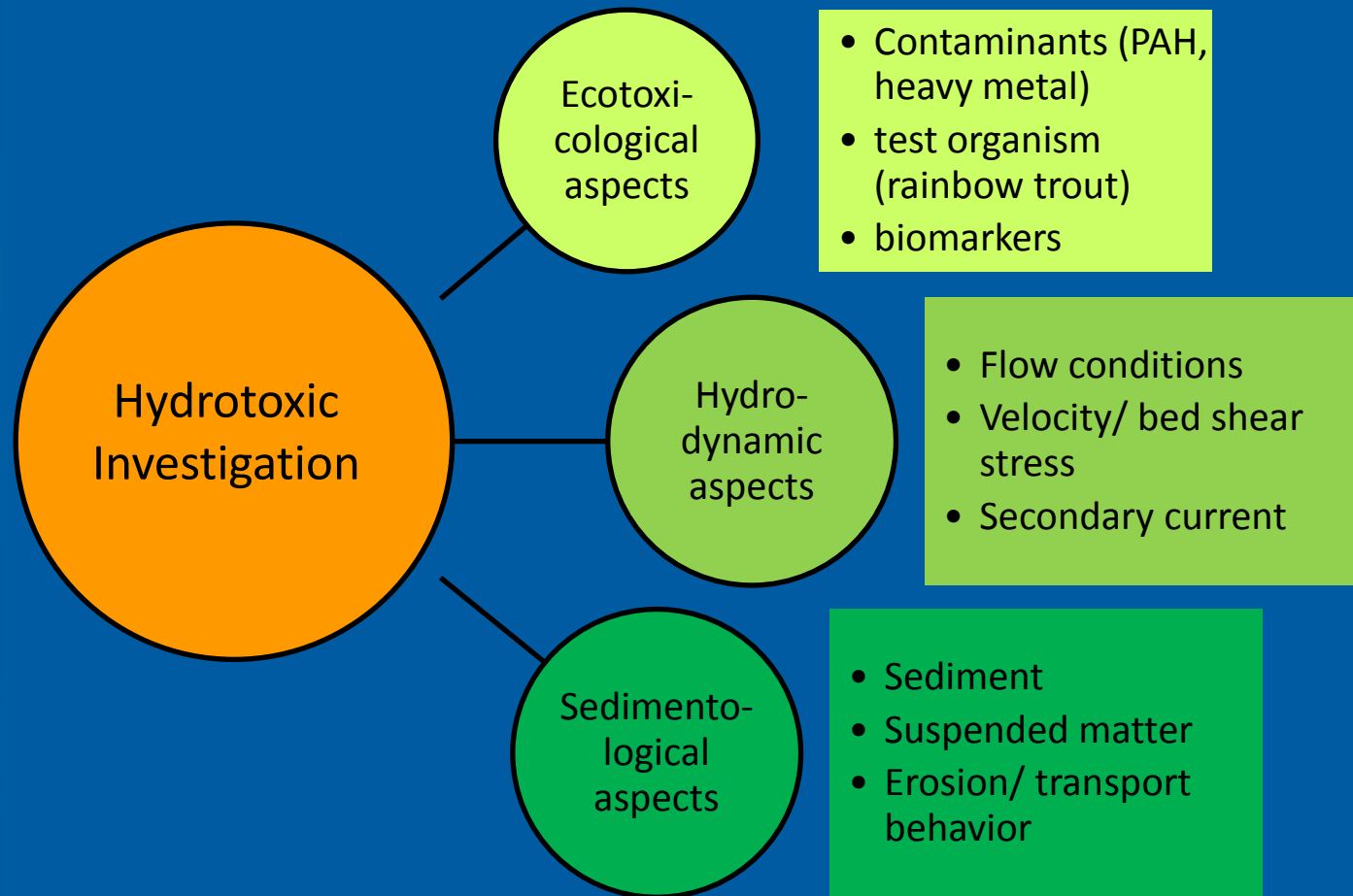
Cologne, 1993, water level: 10.63 m

[www.steb-koeln.de/statistik.html](http://www.steb-koeln.de/statistik.html)

- Cohesive sediments:
  - are sink and source of contaminants
  - can bind contaminants due to their surface characteristics
  - re-suspend during hydrodynamic events: floods, dredging
  - deposit in areas of reduced flow: basins, reservoirs
- re-suspended sediments can harm the aquatic environment
- Transport behavior of sediment helps to track contaminants
- Bioavailability and bioaccumulation of sediment/ SPM bound contaminants are important parameters to assess ecological risk

# The approach

Bridging the gap between engineering and natural sciences



Investigating the processes in a near-natural approach in a laboratory test stand

## Methods: annular flume

- Uniform, endless and steady current
- Investigating the transport behavior of cohesive sediment
- Rotation of channel and lid in opposite direction → reducing secondary eddies
- Known parameters: velocity, bottom shear stress



## Methods: Discrete sampling

- Interactive sampling unit
- Sampling volume: 250 ml
- Max. sampling volume: 10 l (40 times)
- Samples can be taken in two different depths
- Sample volume is replaced



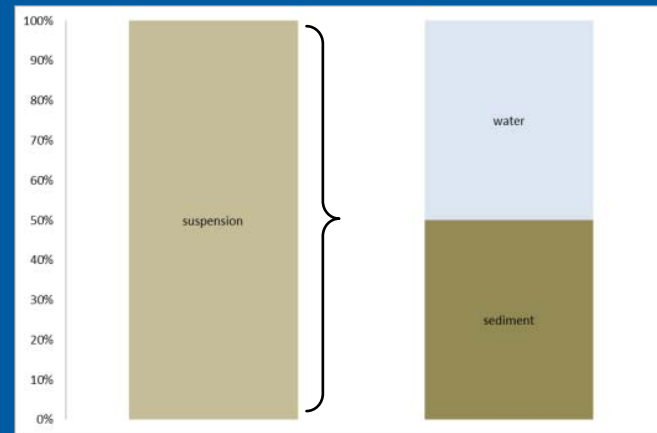
# Methods: Analyzing SPM

## Sedimentological analysis:

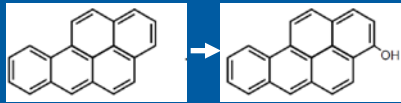
- Estimate Suspended Particle Matter (SPM)
- Calibrate turbidity measurement
- Characterize erosion/ transport behavior (erosional resistance)

## Ecotoxicological and chemical analysis:

- Unspecific cell toxicity:
  - Cytotoxicity with permanent cell line RTL-W1
- Dioxin-like activity
  - EROD assay with permanent cell line RTL-W1
- Determination of PAH concentrations via gas chromatography mass spectrometry (GC-MS)

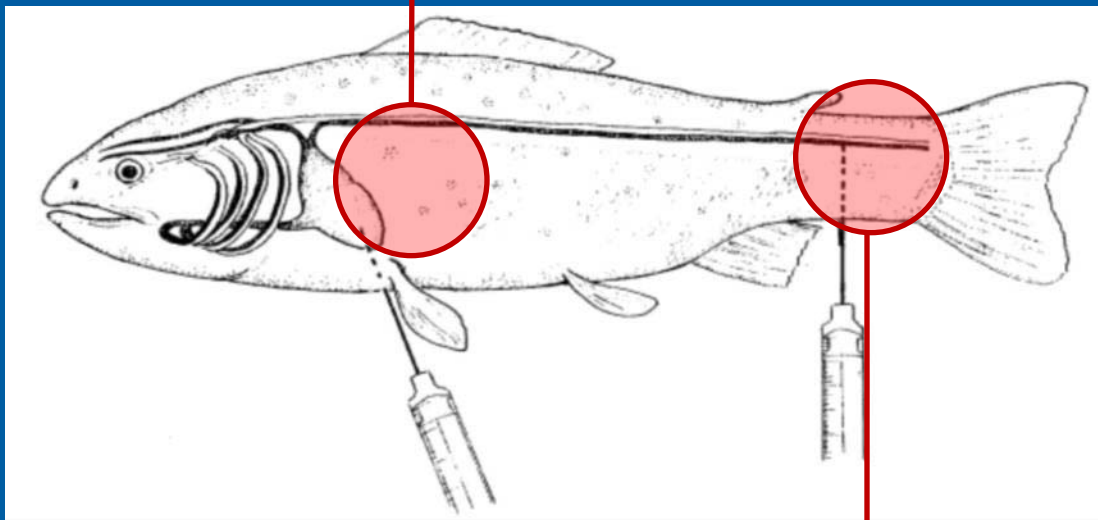


# Methods: Biomarker of exposure

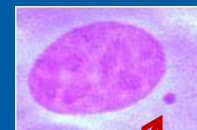


Bile: Quantification of PAH metabolites (e.g. 3-Hydroxy-benzo[a]pyren)

- Measurement of PAH uptake
- Metabolites are formed by attachment of hydroxyl group to target chemicals



Blood: determination of micronucleus frequency in 2000 red blood cells (genotoxicity)





# Material: test organism

Rainbow trout (*Oncorhynchus mykiss*)

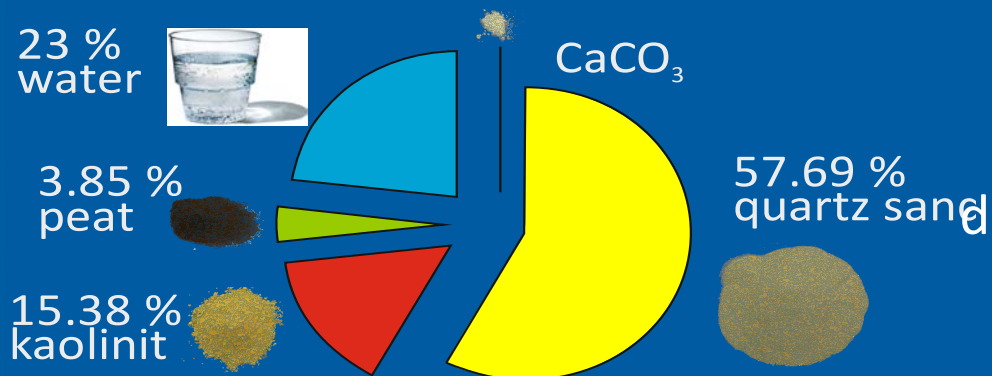
- Good data base
- Good availability, easy maintenance, low-priced
- Representative for moderate climate and river systems
- Suitable size to expose in the annular flume
- Suitable size to gain sufficient sample material to measure several biomarkers



# Material: Sediment types I

## Artificial sediment:

- Proof-of-concept study
- OECD guideline 218
  - Standard in ecotoxicological investigations
- Known composition
  - Reproducibility
  - 3 dry components
  - uncontaminated



# Material: Sediment types II

## Natural Sediment from the River Rhine (Location: Koblenz-Ehrenbreitstein, Germany)

- Complex mixture
- The sediment is defined as moderately polluted
- The sediment was used in various ecotoxicological investigations
- Good knowledge basis for hydro-toxic tests

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## Reference Sediment

### Kaolinite:

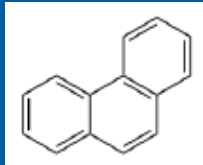
- Homogenous single component
- Grain size: 1.4  $\mu\text{m}$
- Good knowledge basis for sedimentological experiments



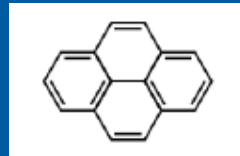
# Material: Contaminants

## Polycyclic aromatic hydrocarbons (PAH):

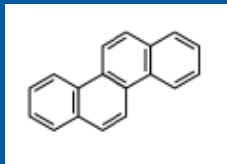
- Origin: partial combustion of organic material
- ubiquitous appearance in sediments in German rivers
- Good data base on biological effects (e.g. carcinogenicity and genotoxicity)
- Emission direct to water: 0.35 t in Germany, 2004 , EPER



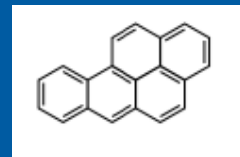
phenantheren



pyrene



chrysene



benzo[a]pyrene

## Heavy metal:

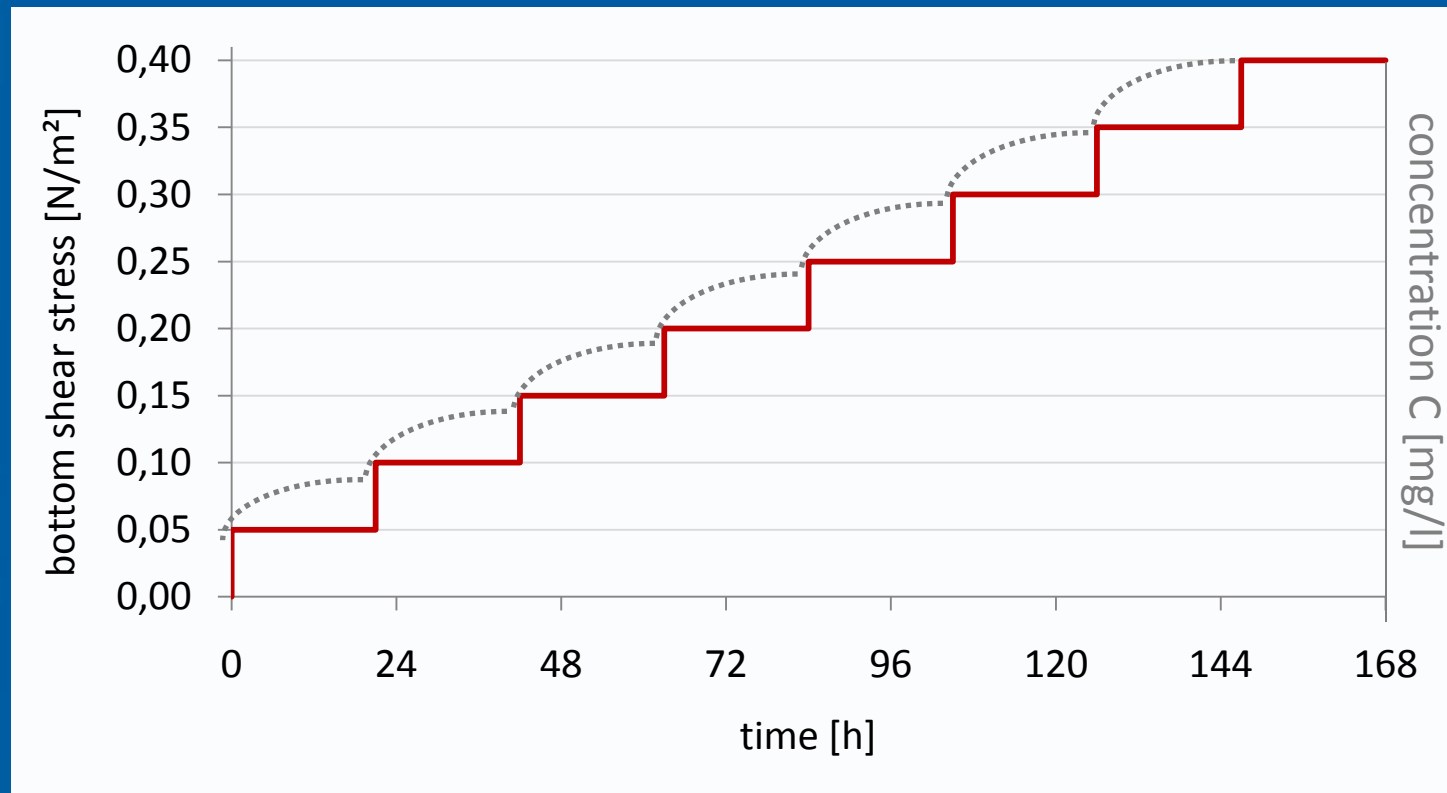
- Copper (Cu)
- Germany has the third largest emission in the EU (16.06 % of European total)
- Emission direct to water: 26.65 t in Germany, 2004, EPER



[www.abendblatt.de](http://www.abendblatt.de)

# Material: load variation

- Stepwise alteration of bottom shear stress
- State of equilibrium of erosion and sedimentation for each step
- Compromise between total exposure time of fish and technical restrictions of test stand
- Consolidation duration: 7 days



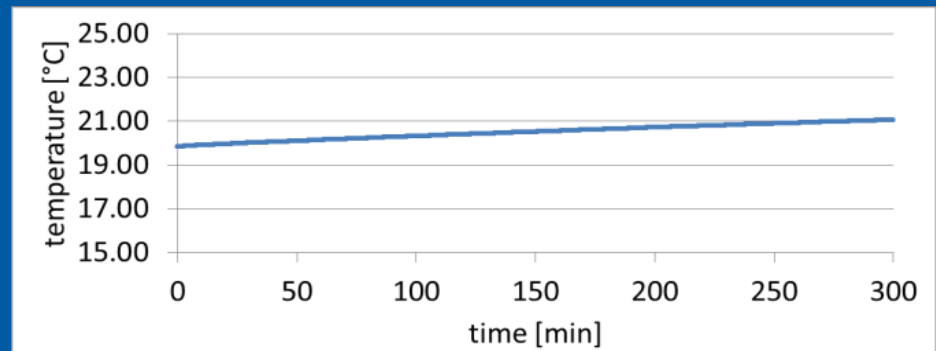
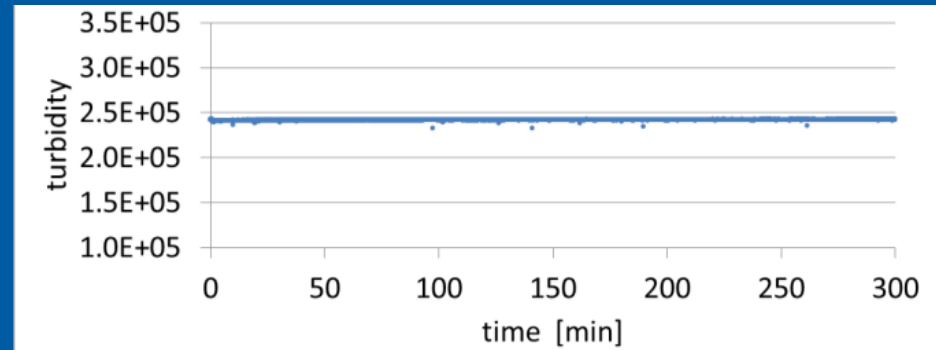
# Test program

	Sedimentological experiments				Ecotoxicological experiments			
	kaolinite sediment from river Rhine				sediment from river Rhine			
Contaminant	-	Cu	Cu	PAH	-	Cu	Cu	PAH
Test organism	-	-	-	-	trout	trout	trout	trout
pH value	8.0	8.0	6.0	8.0	8.0	8.0	6.0	8.0

Tap water:  
without sediment and  
contaminants, with fish

# Results

- Pre-Experiments running at the moment
- Preliminary results
- Characterization with low concentrations  $C=250$  mg/l
- No cooling and aeration
- Data from pH, oxygen content, redox and conductivity not shown



# Summary and outlook

Successful combination of engineering and natural science!

The proof- of-concept study showed that it is possible...

- ... to spike and re-suspend sediment (175 kg) in the annular flume
- ... to expose fish to the sediment in the annular flume without any fatality
- ... to find positive biomarkers (see Poster no. 16 of S. Hudjetz et al.: *A multiple biomarker approach to assess the toxicity of re-suspended sediments during simulated flood events – a feasibility study*)
- ... to characterize the sediment

Currently running:

- Tests without fish progress as expected
- More specific tests to characterize transport behavior of sediments

Further studies and outlook:

- Ecotoxicological experiments with fish
- Hydro-toxic analyses of various natural sediments and further organisms (e. g. crayfish)
- Marine conditions





Thank you for your attention

