Comparison of bioavailability & effects of Cu in two lentic freshwater microcosm studies

Christoph Schäfers,
Heinz Rüdel, Udo Hommen

Fraunhofer Institute
for Molecular Biology
and Applied Ecology (IME)
Schmallenberg, Germany

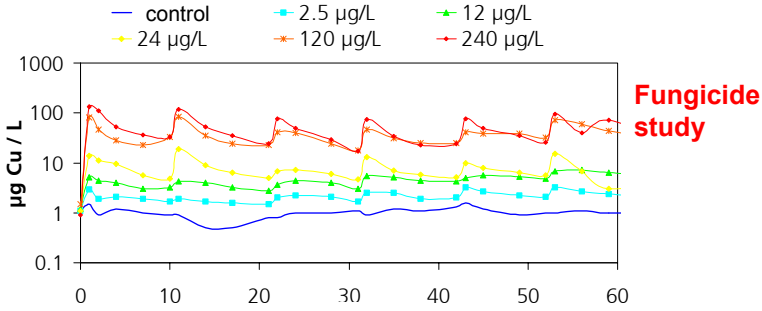
Fraunhofer Institut Molekularbiologie und Angewandte Oekologie

The compared studies - objectives

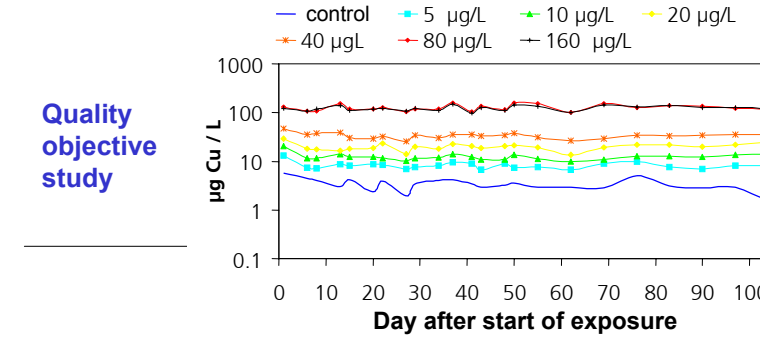
Study objective	
Higher tier risk assessment study for a copper based fungicide:	Setting water quality objectives for copper:
• Community level effects after worst case use (wine)	• Community level effects of a continuous copper exposure
• Time until and extent of recovery	• Adaptation? Active Cu species?
Applied copper salt	
WP-formulated Cu-hydroxide	Cu-sulphate
Dosing	
spraying on the water surface 6 applications every 10 days	Continuously (3 x weekly) adding a solution equilibrated for 24 h
Nominal concentration (µg total Cu/L)	
2.5, 12, 24, 120, 240	5, 10, 20, 40, 80, 160
Total amount of Cu applied (g)	
0.01, 0.05, 0.11, 0.54, 1.08	0.04, 0.08, 0.18, 0.40, 0.76, 1.56
Dosing: 50 d; observation: 385 d	**study duration** 112 d

Fraunhofer Institut Molekularbiologie und Angewandte Oekologie

Concentration of dissolved Cu (0.45 µm filtered)



Fungicide study



Quality objective study

The compared studies – common aspects

- Indoor systems with additional illumination (1 KW metal halid lamps)
- Volume of the microcosms: approx. 1m x 1m X 1m
- Sediment layer of 20 cm
- Design (2 replicates/concentration, 4 controls) and statistics
- Water and included planktonic community of the same source
- Observed endpoints
  abundances of phyto- and zooplanktonic species and of benthic macroinvertebrates,
  production of macrophytes (*Elodea densa*),
  water parameters
- Simulated seasons during application (early to late summer)

The compared studies – nutrient state

Water from the same source („pristine“ reference site)

sediment

Fungicide study		**Quality objective study**
fish pond		„pristine“ reference site (small lake)
TOC: 4.5 %		TOC: 2 %

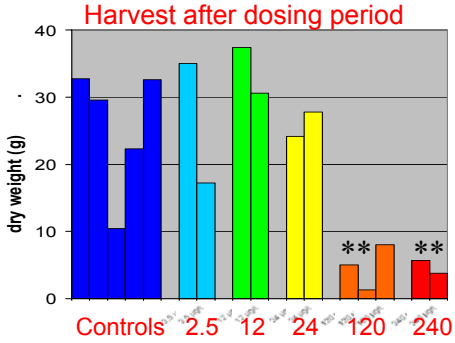
resulting microcosm water at study start

8 mg/L	DOC	4 mg/L
0.5 mg/L	total phosphate	< 0.1 mg/L
4-5 mg/L	nitrate	4-5 mg/L
< 0.1 mg/L	ammonium	< 0.1 mg/L

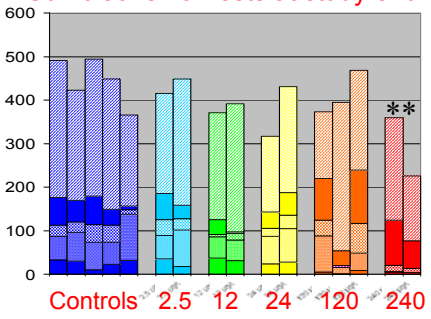
Fraunhofer IME Institut Molekularbiologie und Angewandte Oekologie

Biomass production of macrophytes (*E. densa*)

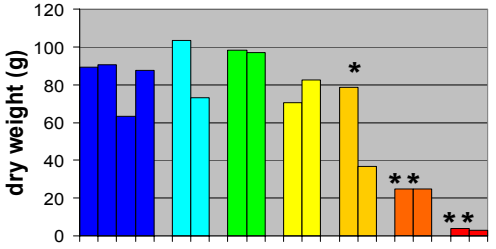
Harvest after dosing period



Cumulative harvests at study end



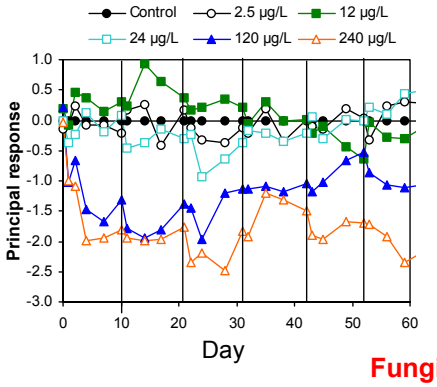
Fungicide study



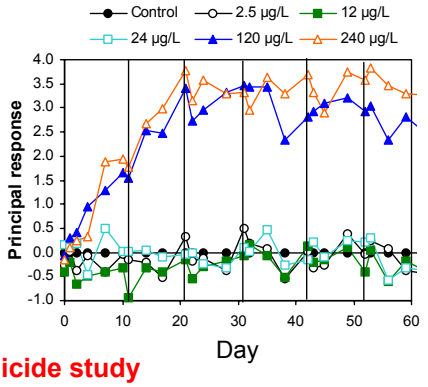
Quality objective study Controls 5 10 20 40 80 160

Plankton community PRCs

Zooplankton



Phytoplankton



Fungicide study

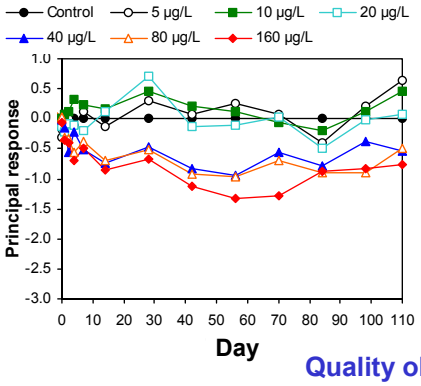
Slight temporary zooplankton effect at 24 µg/L caused by *Chydorus sphaericus*

After the dosing period:
NOEC = 24 µg/L
LOEC = 120 µg/L

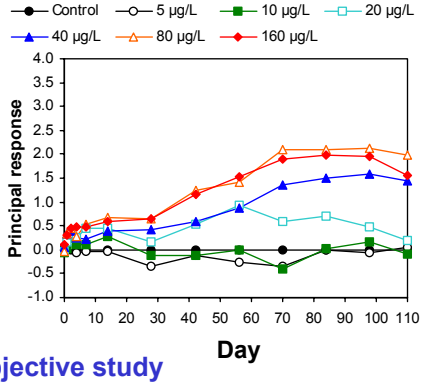
Fraunhofer IME Institut Molekularbiologie und Angewandte Oekologie

Plankton community PRCs

Zooplankton



Phytoplankton



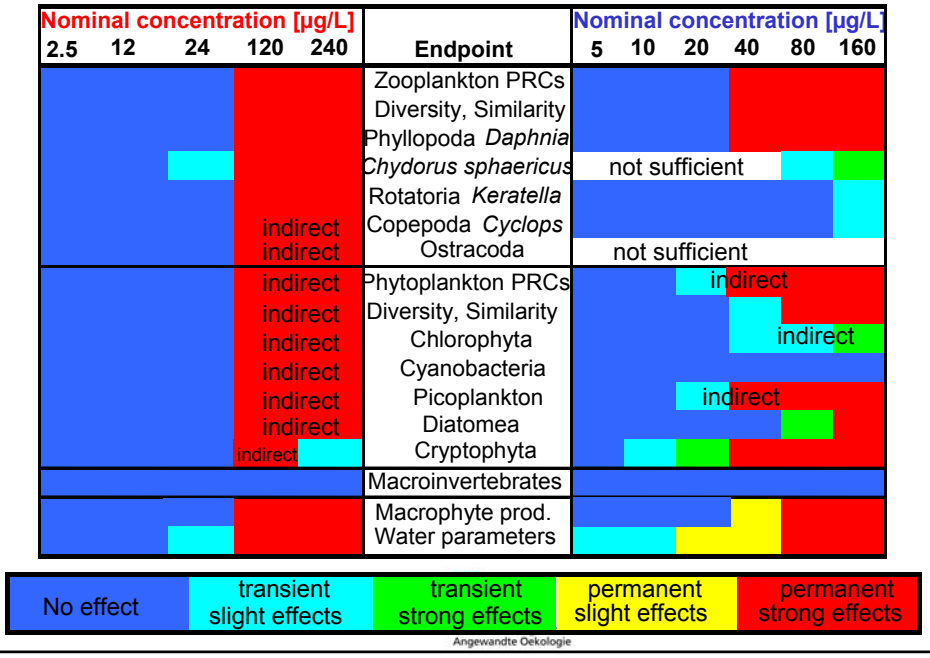
Quality objective study

Temporary phytoplankton effect at 20 µg/L mainly caused by Picoplankton

At study termination:
NOEC = 20 µg/L
LOEC = 40 µg/L

Fraunhofer IME Institut Molekularbiologie und Angewandte Oekologie

Summary: population and community effects



Angewandte Oekologie

Additional information: Recovery

Fungicide study:

After day 50, no further application was performed until the end of the study (early summer if the following year).

All endpoints observed showed full recovery up to nominally 120 µg/L.

At 240 µg/L, only macrophyte biomass production was not able to catch up with the controls.

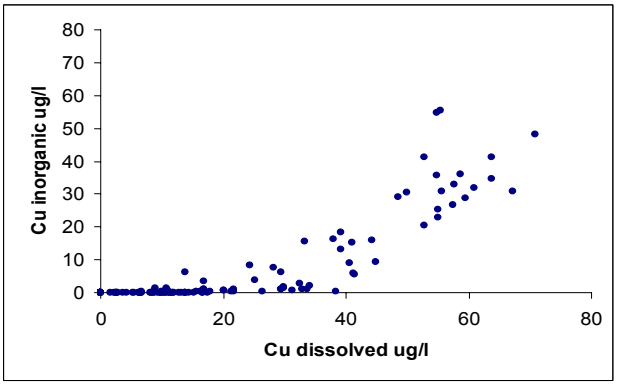
The study was sponsored by the European Copper Task Force, and monitored by

SPIESS URANIA

Fraunhofer Institut Molekularbiologie und Angewandte Oekologie

Additional information: speciation/complexation

Quality objective study



The copper complexation capacity of the microcosm water was determined to be 20 to 30 µg Cu/L.

The study was sponsored by the ICA, represented by the European Copper Institute (ECI),

and performed in cooperation with WRc-NSF, UK

Fraunhofer Institut Molekularbiologie und Angewandte Oekologie

Discussion

Similar results (despite dosing regimen and applied copper salt):

- No observed effect on sediment organisms
  => no bioavailable active copper species in sediment
- Comparable effects on plankton and macrophytes
  => formulation seems to compensate for solubility
- Threshold concentration for effects around 20 µg/L
  => copper complexation capacity of oligotrophic lentic systems is able to eliminate bioavailable active copper species up to 20 µg/L

Differences:

Fungicide study	**WQ objective study**
high plankton density	low plankton density
effects more pronounced	effects more sensitive
higher complexation capacity?	less compensatory potential

Fraunhofer Institut Molekularbiologie und Angewandte Oekologie

Conclusions

High dynamics (high nutrient levels, spring conditions)

- effects on growth and reproduction amplified
- indirect effects dominant
- suited for outdoor studies

Low dynamics (low nutrient levels, summer conditions)

- communities exploiting habitat capacity
- effects less amplified
- direct effects more sensitive
- suited for managed indoor studies

Fraunhofer IME Institut Molekularbiologie und Angewandte Oekologie

Differentiated Taxa (69)

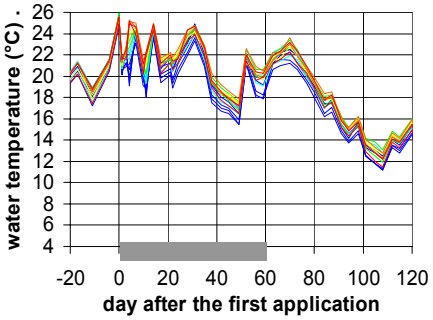
Zooplankton (13 taxa)	Copepoda (adults, nauplii)	2
	Ostracoda	1
	Cladocera	5
	Rotatoria	5
Benthic macro-Invertebrates (11 taxa)	Odonata	2
	Coleoptera	1
	Trichoptera	1
	Chironomidae	1
	Brachycera	2
	Megaloptera	1
	Bivalvia	1
	Tubificidae	1
	Hirudinea	1
Benthic Meiofauna (14 taxa)	Nematoda	14
Macro-phytes (1 taxon)	*Elodea densa*	
Filamentous Algae (1)	Chlorophyta	
Phyto-Plankton (29 taxa)	Cyanophyta	4
	Crypto-phyceae	3
	Chlorophyta	14
	Conjugato-phyceae	3
	Diatomea	2
	Eugleno-phyceae	1
	Picoplank-ton < 5µm	1
	Unknown	1

Fraunhofer IME Institut Molekularbiologie und Angewandte Oekologie

Temperature in the microcosms

Simulation of early summer to early autumn

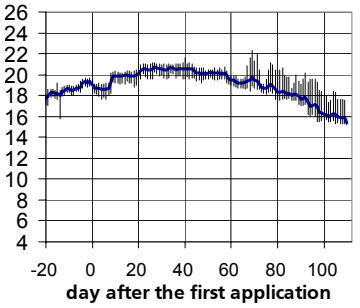
Fungicide study



By adjusting room temperature to the outdoor temperature

grey: compared dosing period

Quality objective study



By temperating the water

vertical lines: daily max, min

Fraunhofer Institut Molekularbiologie und Angewandte Oekologie