Impact of the biocide Irgarol on the phytoplankton community in freshwater pond mesocosms

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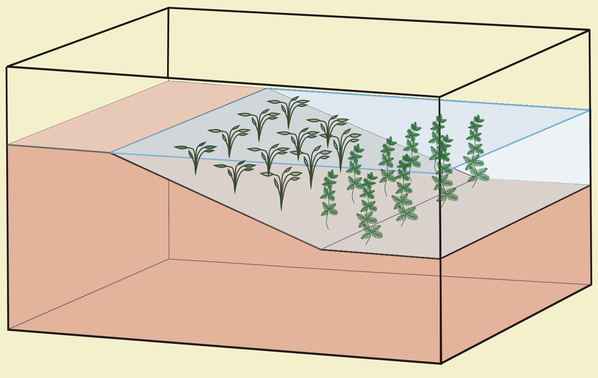

Fig. 1: Schematic overview of the mesocosm pond incl. littoral zone and macrophytes

Introduction

As photosystem II inhibitor, the commonly used antifouling component Irgarol is highly toxic to algae (e.g. 5-d-EC50 for *Navicula pelliculosa*: 0.1 µg/L). Although many studies on environmental concentrations of Irgarol have been reported mainly from marine sites, there are only data from single species toxicity tests and 1 microcosm studies on the effects of Irgarol available. Up to now, there are no data on the effects of Irgarol on freshwater phytoplankton communities at the mesocosm scale. Therefore, effects of Irgarol on phytoplankton communities were investigated by the German Federal Environment Agency in the framework of an indoor pond mesocosm study.

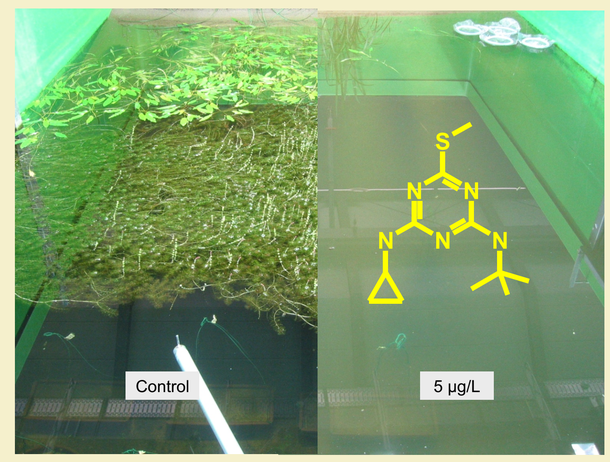

Fig. 2: Control pond and treated pond contaminated with 5 µg/L Irgarol (14-06-05)

Materials & Methods

Pond design

Size: length 690 x width 325 x height 250 cm
Water volume: c. 15 m^3
Artificial light: mean 13,000 lx
Nutrient regime: Tot-P >0.02 mg/L; Tot-N >0.7 mg/L

Biological establising

Pond bottom: Sand, natural fine sediment, littoral zone (Fig. 1)
Macrophytes: *Potamogeton nodosus and Myriophyllum verticillatum* (Fig. 1) (**effects on macrophytes see: Berghahn *et al*. 2006 - SETAC**).
Stocking: Plankton and macro-invertebrates from nearby mesotrophic lakes and ponds

Experimental design

- Single application of Irgarol (11-04-05) by spraying a methanolic stock solution on the water surface. Homogenisation by use of a battery driven outboard motor and air ventilation on the water surface. Spiking with 6 different nominal concentrations: 0.04 (1 pond), 0.2 (2 ponds), 1 (1 pond), and 5 µg/L (2 ponds). Two ponds served as controls.

Sampling & analysis

- Water samples for the detection of Irgarol and selected metabolites were taken at first in three-hour intervals after dosage, gradually extended to a fortnightly sampling interval (details see: Fig. 3, **fate of Irgarol see: Meinecke *et al*. 2006 - SETAC**)
- Integrated phyto- and zooplankton samples (10 sites per pond) were taken fortnightly. Phytoplankton samples were preserved by adding Lugol-solution.
- Phytoplankton analysis followed standard procedures by use of Utermoehl-technique. Abundance as well as biovolume were detected.

Data evaluation

- EC50 calculation by Probit analysis (SPSS 11) and analysis of phytoplankton community response using principle response curve (PRC) (CANOCO V 4.5).

Analytics

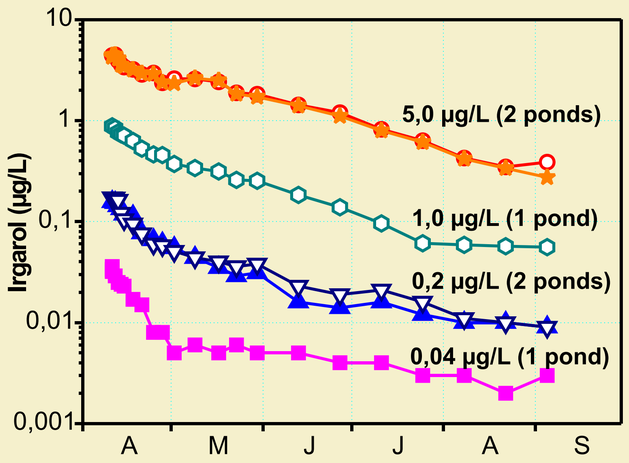

Fig. 3: Irgarol concentration in the water column of the 6 treated mesocosm ponds.

Results

Phytoplankton composition

- Cryptomonads and diatoms were dominating in all systems during the study, whereas green algae, chrysophytes, and blue-greens appeared temporarily (Fig. 4).
- Above the 0.2 µg/L-concentration level, strong adverse effects were observed on both dominating groups - the cryptophytes (*Cryptomonas* spp.) and diatoms (*Fragilaria ulna*) - 8 and 21 d after treatment, resp. (Fig. 4) as well as on macrophytes (Fig. 2).
- In the 0.2, 1.0 and 5.0 µg/L-ponds, reduction of abundance and biomass followed an effect-concentration relationship, whereas in the 0.040 µg/L-pond, phytoplankton biomass increased directly after application (Fig. 5).
- Recovery of higher taxa occurred even on the highest treatment level, at first by small centric diatoms, partly followed by cryptophytes and green algae. However, differences in species composition between the treatments were obvious (Fig. 4-6).

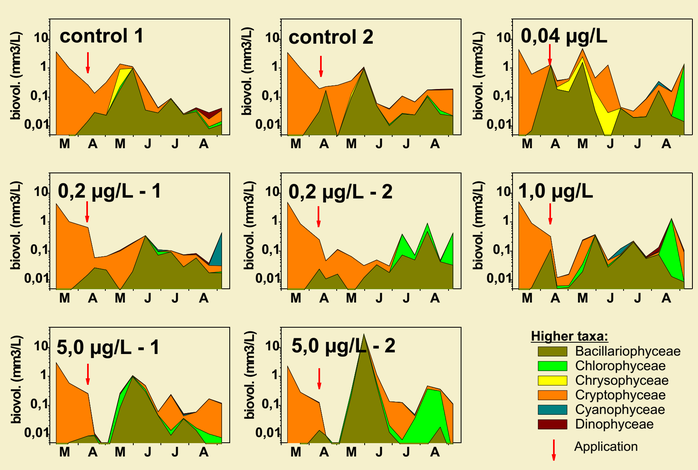

Fig. 4: Cumulative biomass of main phytoplankton groups (higher taxa).

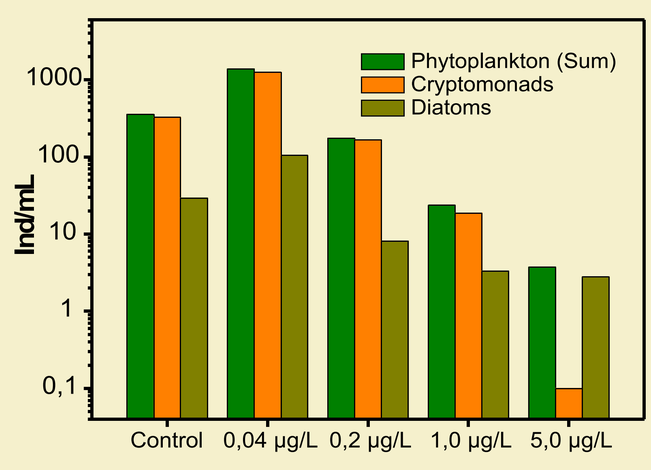

Fig. 5: Abundance of main phytoplankton groups (higher taxa) 8 days after application.

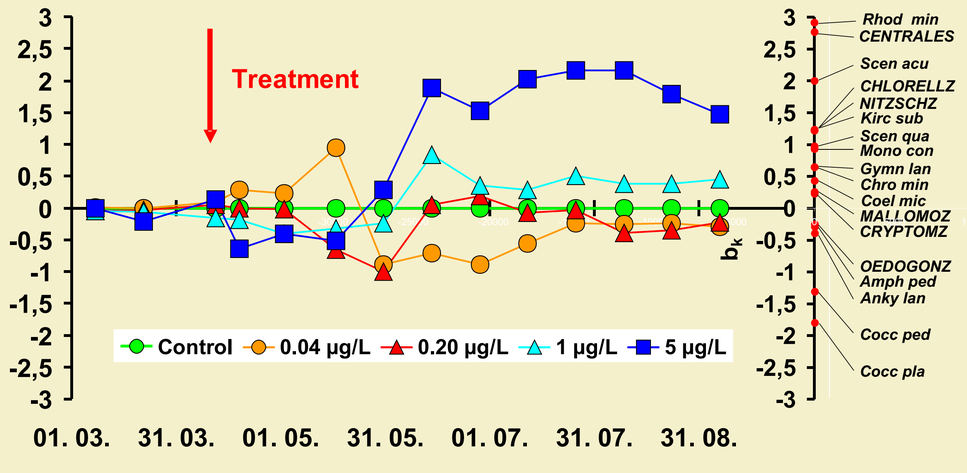

Fig. 6: PRC-analysis of the phytoplankton community. Bk value = species weight (only range > or < 0,2 units is given).

Principal Response Curve

- The treatment regime as a whole (sum of all canonical eigenvalues) represented c. 53 % of the variance of the data set (P: 0.004) (Fig. 6).
- By use of Monte Carlo permutation testing (all can. axes) all sampling dates >= 8 d after treatment indicated significant differences (P < 0.05) between the treated ponds (as a whole group) and the control ponds.
- According to bk-values, the benthic algae species *Cocconeis* spp., *Ankyra lanceolata*, *Amphora pediculus*, and *Oedogonioum* sp. decreased in this study, whereas planktonic taxa like centric diatoms and the cryptomonad *Rhodomonas minuta* were promoted by Irgarol application (**effects on periphyton see: Mohr *et al*. 2006 - SETAC**) .

Conclusions

- Most EC50 data from laboratory testing (Fig. 7) are below the 2 µg/L level (data set from 5 publication: micro- and macro-algae and vascular plants, freshwater and marine species).
- Adverse effects on the mesocosm level (this study) were found in the lower EC50-range between 0.04 and 1.0 µg/L 8 and 21 days after application (higher taxa: only by range indication, 8-d-EC50 for *Cryptomonas* spp.:0.069 µg/L by probit analysis) (Fig. 7), confirming the high herbicidal toxicity of Irgarol.
- Although recovery appeared to some extent - even on the highest treatment level (see: Solomon et al. 1996 - atrazine) - significant differences at the community level were observed on almost all sampling days, indicating a relevant shift in species composition and abundance after application.

References: Bérard *et al*. 2003, Chesworth *et al*. (2003), Jones & Kerswell (2003), Readman *et al*. (2004), Okamura *et al*. (2000a), Solomon *et al*. (1996), US EPA (2000)

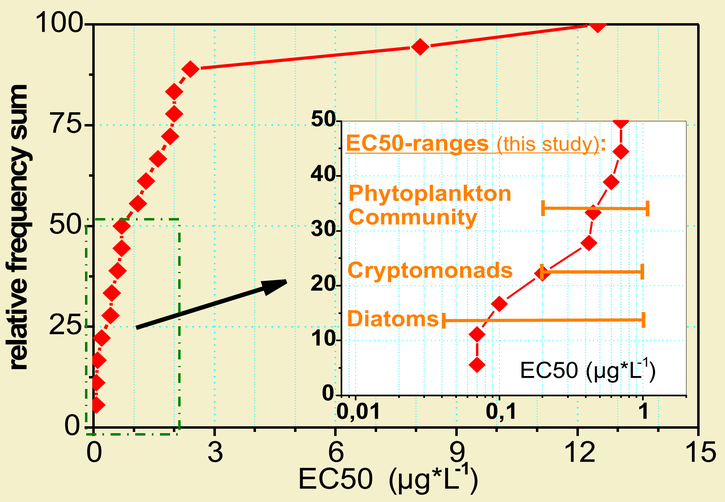

Fig. 7: Species distribution of EC50-values of algae and vascular plants from published lab tests compared with effects of phytoplankton groups from this mesocosm study (8 and 21 d after application).