

Are TKTD Models for Algae and Macrophytes Sufficiently Protective in a Community Context? A Simulation Study

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The dilemma

- Modified exposure experiments and TKTD (Toxicokinetic-toxicodynamic) models [1, 2] are used to address time-variable exposure in the risk assessment of plant protection products in the EU (Tier 2C)
- For animals and also for rooted macrophytes, Tier 1 and Tier 2C studies analyse effects on organism level endpoints (survival, development, growth, reproduction)
- For algae and the duckweed *Lemna*, the Tier 1 endpoint is inhibition of the population growth rate (r)
- Thus, for these tax damage repair on organism level but also recovery of population growth are assessed in Tier 2C
- However, ecological recovery should usually only be assessed at Tier 3 within a community context (e.g. a mesocosm) [1]

But is it really 'ecological recovery' here?

- 'Ecological recovery is the return of the perturbed ecological endpoint (e.g. species composition, population density) to its normal operating range' [3].
 - Tier 3: the duration of effects on abundance or biomass should be shorter than 8 weeks in mesocosms
 - Tier 2C: due to exponential growth, abundance cannot recover => instead recovery of growth rate is assessed
- Population growth of algae and *Lemna* is comparable to growth of individual animals or rooted macrophytes

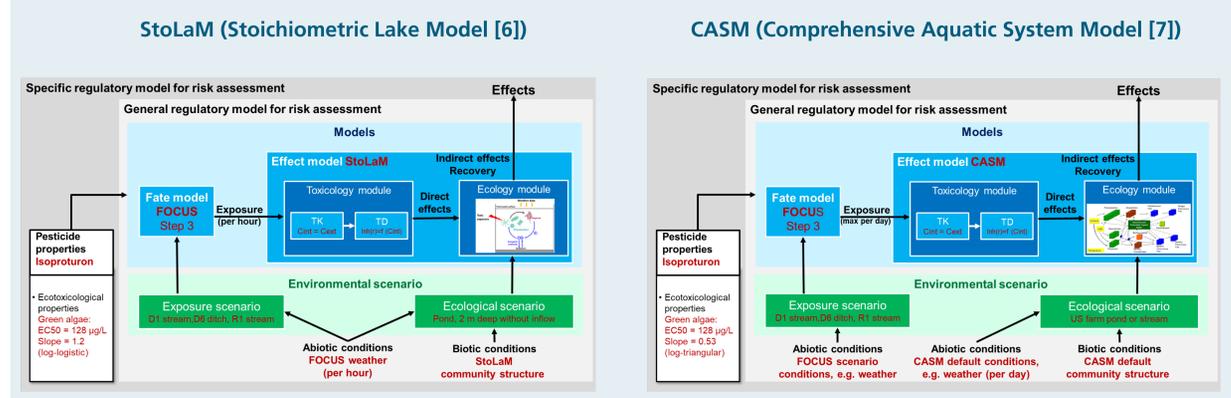
A pragmatic approach to address the level of protection

- Hypothesis: **Tier 2C is acceptable if it leads to acceptable effects under the ecological threshold option in an ecosystem setting:**
 - In Tier 2C, the EP50 defines the factor by which the original PEC profile can be multiplied before the population growth rate is reduced by 50% (Tier 1 endpoint)
 - In Tier 1, profiles which do not exceed the ErC50 divided by the assessment factor of 10 are accepted
 - Using the same factor, EP50 > 10 are acceptable at Tier 2C
 - Thus, PEC x EP50 / 10 should have acceptable effects within the ecosystem context
- Approach: Testing effects of acceptable profiles according to Tier 2C using different ecological scenarios by means of aquatic ecosystem models

Effects of isoproturon on green algae as example

- The Tier 1 ErC50 is 128 µg/L => Tier 1 RAC = 12..8 µg/L [4]
- Tier 2C calculations were conducted for 3 example exposure FOCUS profiles: D1, D6 and R1 by Rendal et al. [5]
 - All example profiles fail Tier 1
 - Tier 2C only refines the R1 scenario (EP50 = 2693) while the EP50 for the drainage scenarios are < 10
- Therefore, we checked the effects of the proposed acceptable exposure profile R1 by simulating the R1-PEC x EP50 / 10
- Use of four community structures (Figure 2)
 - Only 4 algae (including 1 green algae) and the same 4 algae plus *Daphnia* as consumer using StoLaM [6]
 - The default stream and a pond food web by CASM [7] with 20 algae including up to 7 green algae
- Here, only the single green algae (StoLaM) or the dominant phytoplankton of periphyton green algae (CASM) was considered to be sensitive (ErC50 = 128 µg/L) to create a worst-case situation for recovery

Conceptual models

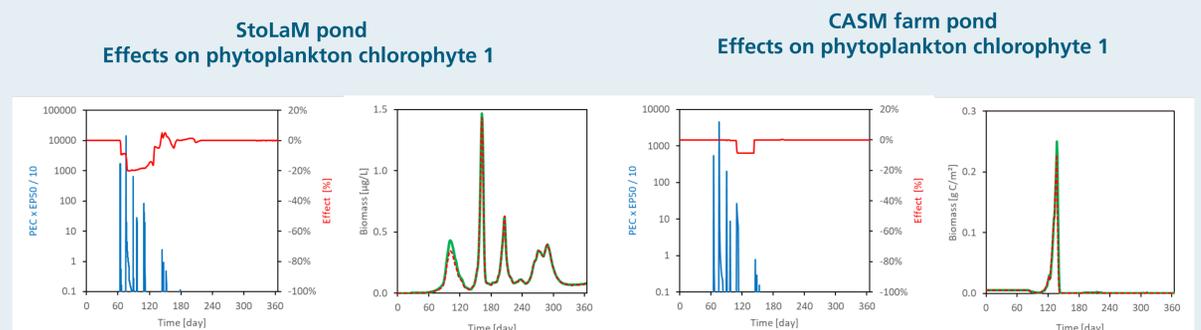


Results

- If only 4 algae are considered in StoLaM, effects up to 25 % on daily biomass are predicted but only during a period of low biomass
- If *Daphnia* is included as grazer, the maximum predicted effect is 20 % (see figure below)

- In the more complex CASM food web, effects on daily biomass were less pronounced than in StoLaM
- The largest effect of the EP50 / 10 exposure profile was below 10 % for the dominant green algae in the phytoplankton (see figure below)
- Effects on the periphyton green algae in the CASM pond and the stream were hardly visible (not shown)

Example results for a run-off profile refined by Tier 2C modelling – effects of FOCUS-PEC x EP50 / 10



The EP50 / 10 PECs for CASM are lower than for StoLaM because StoLaM uses hourly PEC values while CASM uses only daily daily PEC values. Therefore, the Tier 2 simulations for CASM were done with the maximum PEC per day which resulted in a lower EP50 of 859 compared to 2693 for the hourly PEC values with faster dissipation.

Preliminary conclusions

- Effects of the exposure profiles which are acceptable according to Tier 2C refinement for algae can result in visible effects on biomass dynamics of the affected algae in a community context
- In a simple community, effects are more pronounced than in a more diverse community
- However, the predicted effects can be considered acceptable.
 - In the simple simulated community, temporary effects on daily biomass were restricted to periods of relatively low biomass and are small with respect to the dynamics over the full year.
 - In the ecosystem model, effects were < 10%
 - No pronounced indirect effects were predicted
 - None of the effects predicted by the deterministic models would be detectable in mesocosm studies or monitoring studies due to natural variability

Outlook

- Further simulations, e.g. regarding effects of other herbicides on algae or effects on macrophytes with longer duration of Tier 1 tests are planned

References

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- [4] Weber et al. (2012): doi.org/10.1002/etc.1765
- [5] Rendal et al. (2023): doi: 10.1002/etc.5649
- [6] Strauss (2009): PhD Thesis. ISBN 978-3-8322-8501-2
- [7] Bartell et al. (2020): doi.org/10.1002/etc.4843