Area 1 • Terrestrial Ecology + Biology • Commentary

Semi-Field Methods are a Useful Tool for the Environmental Risk Assessment of Pesticides in Soil

Developed on the discussions at the SETAC workshop PERAS, Coimbra, Portugal, October 2007

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Introduction

Only few validated higher tier laboratory or semi-field methods are available to assess structural and functional effects of pesticides in soil. In this context, the SETAC workshop PERAS ('Semi-field Methods for the Environmental Risk Assessment of Pesticides in Soil') was organized in Coimbra, Portugal, 08-10 Oct. 2007, to present and discuss the state of the art with a focus on semi-field methods such as 'Terrestrial Model Ecosystems' (TME). 55 experts from academia, industry and authorities, e.g. EFSA, OECD, and national pesticide registration agencies, were invited from Europe, Brazil and the US. This commentary paper will focus on the workshop discussions on TME studies.

TME may be used for the environmental risk assessment of industrial chemicals, biocides and plant protection products (Weyers et al. 2004). The potential for the use of TME in pesticide risk assessment was mentioned in the EPPO risk assessment scheme for soil organisms and functions in 2000 and also in the Guidance Document on Terrestrial Ecotoxicology under Council Directive 91/414/EEC (SANCO/10329/2002) (European Commission 2002). Whilst TME were proposed as a potential higher tier refinement step, it was not clear precisely how such methods would fit into a tiered risk assessment scheme. This potential for their use may gain importance with the forthcoming revision of Directive 91/414/EEC, regardless of whether the focus of soil risk assessment is on soil 'structure' (i.e. community structure & biodiversity) or soil 'function' (e.g. microbial respiration, litter breakdown) – or both (EFSA 2007, Morgan & Knacker 1994). TME may also fit into the proposed Dutch decision tree for persistent pesticides as a method for higher tier assessment (van der Linden et al. 2006).

Aims of the PERAS Workshop were:

- To highlight the current state of knowledge regarding semi-field methods and to identify most appropriate methods to assess the 'impact' of chemicals on soil community structure and function.
- To give a particular focus on higher tier laboratory and semi-field methods which may be employed between 1st tier laboratory tests and full scale field studies. Special attention was paid to TME study types.
- To discuss technical aspects of the TME method in order to agree, as far as possible, on a standardized test method.
- To identify key gaps in knowledge and areas for further research and development in soil effects testing and risk assessment.

1 Experimental Approaches

1.1 Comparing systems

A set of different tests is available: single species tests, microcosms, mesocosms, enclosures, and field tests, each with a typical combination of experimental design and ecological relevance (**Fig. 1**). Experimental parameters discussed referred to the use of intact soil cores and columns with sieved soil, soils with natural communities and those with added species, open and closed systems, as well as systems kept indoor and outdoor.

In the next step systems were compared in terms of their potential to include various ecological levels and processes, i.e.,

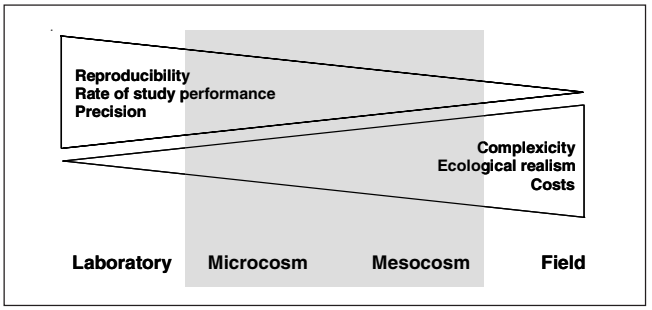

Fig. 1: Comparison of test systems

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whether they address the population or the community level, reflect the intrinsic recovery and natural recolonization, and allow a sensitive detection of effects. Finally, performance criteria of the various systems were discussed, such as the time and effort needed, the reproducibility, experience and guidance available, the state of standardization, the control of environmental variables (e.g., light regime, irrigation), and the ecological relevance, as shown in Fig. 1.

1.2 Terrestrial model ecosystems (TME)

Terrestrial model ecosystems were considered a suitable tool at the semi-field level to assess structural effects on the soil community. The TME should contain undisturbed soil cores, e.g., from an established grassland, containing natural communities, e.g. microarthropods, enchytraeids, nematodes, and microorganisms. Efforts should be made to link and quantify the exposure, e.g. by chemical analyses and modeling, and the effects of pesticides in the TME systems.

However, research for providing technical guidance is needed considering fate and exposure of the test substances: Which type of application techniques should be used for persistent and for readily degradable pesticides? How long should the soil systems be pre-equilibrated before a chemical is applied? Should the environmental conditions during incubation be controlled, such as the irrigation and light regime? For a proper effect assessment suitable soils have to be defined. Which ecotoxicological endpoints, e.g., the community structure of the mesofauna and optionally functional tests should be used? Is it appropriate to include positive controls, i.e. TME to which a toxic standard is added to ascertain the receptiveness of the communities? How should the intrinsic recovery be measured?

General requirements were defined regarding the proper use of TME: (a) pre-screening of the soils should ascertain species homogeneity and sufficient abundance of sensitive organisms. (b) The soil moisture is of key importance for the biological activity and the partitioning of the test substance and certainly has to be controlled. (c) The size of the soil columns both in length and diameter has to be optimized both in terms of the number and size of samples to be taken and the minimization of boundary effects. (d) The sampling frequency is mainly driven by the disappearance rate and fate of the test substance. (e) Appropriate statistics have to be applied to evaluate the experimental results: uni- and multivariate methods should be used (principal response curves); a dose-response design should be applied to derive ECx and NOEC at the community and population levels; the statistical power should be increased by an appropriate number of replicates, and the minimum detectable difference (MDD) should be calculated.

2 Conclusions

TME represent an appropriate higher-tier test system to investigate the impact of pesticides and chemicals on the structure of the soil community and biodiversity. They are able to comprise various trophic levels of the soil community reflecting both direct and indirect effects of chemicals. TME allow for the investigation of the intrinsic recovery of the soil mesofauna. However, field studies allowing for the investigation of recolonisation are ecologically even more relevant than TME studies.

3 Research Needs

Further research is required for the extrapolation of results across soil types, climatic and edaphic regions, and biological communities. It would be eligible to develop a classification scheme scaling the magnitude and the duration of effects, and the recovery. Comparative studies have to be performed in order to determine the variability of data within and between TME as well as those between TME with field tests. It has to be tested whether subsampling within a TME can be applied or whether sacrificial sampling of a TME is more appropriate. If a regulatory distinction is to be made the sensitivity of in- and off-crop communities have to be compared.

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Workshop description: http://www.gaiac.rwth-aachen.de/peras

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Proceedings of the workshop are prepared. Electronic versions of the workshop lectures given can be found at: http://www.gaiac.rwth-aachen.de/peras/	
Welcome and Introduction, Aims of the Workshop	Andreas Schaeffer
Regulatory and Industry views and expectations	Mark Egsmose and Mark Miles
Ecological background and context	Ryszard Laskowski
Regulatory context: Directive 91/414/EEC and future pesticide Regulation	Simon Hoy
Soil risk assessment of persistent pesticides: Dutch proposal and other frameworks	Frank de Jong
Overview and evaluation of soil higher tier methods	Jörg Römbke and Paulo Sousa
Review of methodology and experiences with TMEs	Bernhard Förster and Martina Roß-Nickoll
Summary of the workshop	Paul van den Brink