DEGRADATION OF THE INSECTICIDES PIRIMICARB® AND IMIDACLOPRID® IN INDOOR AND OUTDOOR STREAM MESOCOSMS UNDER DIFFERENT LIGHT CONDITIONS

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Introduction

Figure 1: Indoor stream mesocosm system 106 m length, 1 m width, run in circular mode [5]

Pirimicarb and imidacloprid (Figure 2) are insecticides applied in crop protection against aphids and other sucking or biting insects [1][2]. These compounds may pass into water bodies by spray drift or by run-off after application. Pirimicarb and imidacloprid are described as being readily degradable in natural water bodies by solar irradiation and microbial activity [3][4]. A stream mesocosm study was conducted in order to investigate the influence of solar radiation and microbial activity on the degradation process under natural like conditions. Two scenarios were run. First scenario: Indoor stream mesocosms with established stream community over a 3 year period under artificial light conditions simulated the solar light spectrum in the visible range, but the ultraviolet components UV A + B were very weak. Therefore, any dissipation of both insecticides in the indoor systems should result from microbial degradation only. Second scenario: Water of the indoor streams were pumped to outdoor streams which were exposed to full sun light but an almost undeveloped biocoenosis. Thus, photodegradation of the two compounds should play a more important role besides biological degradation. The concentrations of pirimicarb and imidacloprid in the water columns were monitored both in indoor and outdoor mesocosms (Figure 1).

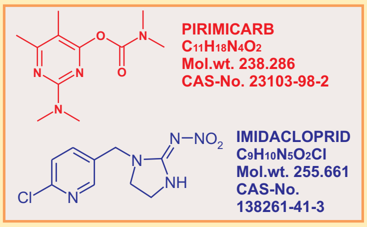

Figure 2: Basic data of both insecticides

Materials and Methods

Indoor stream mesocosms:

Flow velocity: 0.15 m/s
Mean light intensity at the water surface: 29 W/m²
Mean water temperature: 20°C
Biological establishment: sand, natural sediment, macrophytes, macroinvertebrates (3 years of developement)
Nutrient status: mesotrophic

Experimental Design:

Scenario 1: Influence of microbial degradation
Stream systems were spiked separately with 1 µg/L pirimicarb (indoor 1), 10 µg/L pirimicarb (indoor 2), 10 µg/L imidacloprid (indoor 1), 10 µg/L imidacloprid pulse exposure of 5 h (indoor 2, data not shown)

Scenario 2: Influence of radiation
After a residence time between 8 and 12 weeks, the free water of the contaminated indoor mesocosms was released to outdoor mesocosms where it was exposed to solar radiation and the prevailing meteorological conditions (pirimicarb outdoor 2 and imidacloprid outdoor 1 and 2)

Outdoor stream mesocosms:

Flow velocity: 0.15 m/s
Global irradiation: mean values of 74 W/m² (autumn sun), optimal exposure of 88 m² of water surface to the sun
Outdoor air temperature: mean value of 8.9°C
Biological establishment: sand, natural sediment; biofilms and filamentous algae developed after filling with water from the indoor systems
Nutrient status: mesotrophic

Chemical and statistical analysis:

- The method of the derivatisation of imidacloprid for the detection by gas chromatography/mass spectrometry (GC-MS) [6] was modified.
- Pirimicarb and imidacloprid in water samples were analysed as shown in Figure 3.
- Concentrations measured in the water samples were corrected to the volume at the start of each experiment.
- The dissipation of both insecticides in the water column was fitted to a first order degradation curve (Table 1) following the equation: $C(t) = Co \cdot \exp[-k \cdot t]$

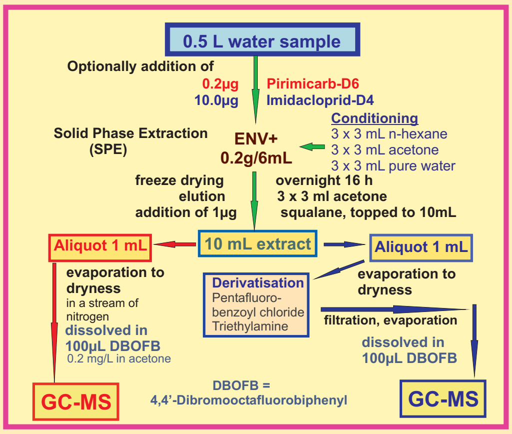

Figure 3: Flow chart of the analytical method

Results and Discussion

The indoor DT50 for pirimicarb were in the same range as described from a water-sediment study performed in the dark (Figure 4) [3]. The DT50 in the indoor systems were about 2.6 to 3.4 times higher than in the outdoor systems despite considerable biological activity and higher water temperatures (Figure 5).

The DT50 of imidacloprid in the indoor system exceeded the indoor residence time (Figure 6) and had to be extrapolated (Table 1). The resulting DT50 of 75 days in the water column was about 4 times longer than shown in a water-sediment study with radiolabeled imidacloprid [4]. Very similar DT50 of imidacloprid were found in the outdoor study (Figure 6, 7).

The radiation of the autumn sun increased the degradation rate of pirimicarb and imidacloprid considerably in the outdoor stream mesocosms, compared to the indoor systems. However, a fast elimination of both compounds within a few hours or a DT50 < 1 d as described for water bodies under solar radiation [3][4] could not be observed. The outdoor experiments could be described a best case scenario since 84% of the water surface was exposed to full sunlight and the water in the mesocosms was clear and uncoloured. Turbidity and shaded zones in natural water bodies are likely to prolong the DT50 of photosensitive compounds such as pirimicarb and imidacloprid. Photosensitive insecticides are often applied at dusk or at night and may then enter surface waters many hours before photodegradation can start.

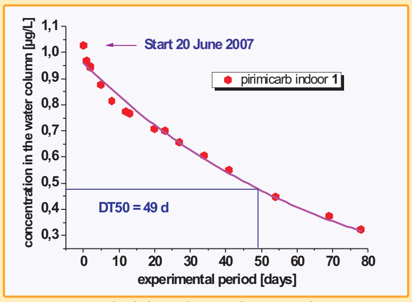

Figure 4: Microbial degradation of pirimicarb

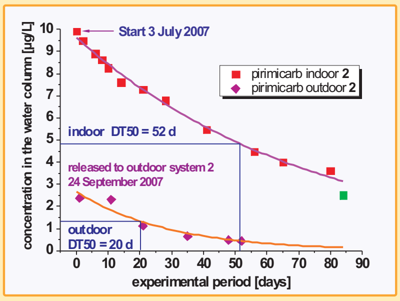

Figure 5: Microbial and photolytic degradation of pirimicarb

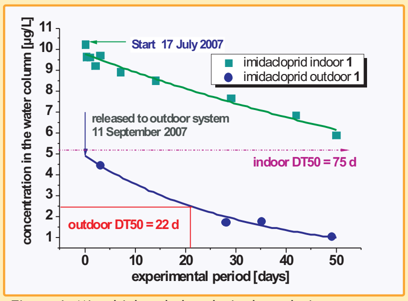

Figure 6: Microbial and photolytic degradation of imidacloprid

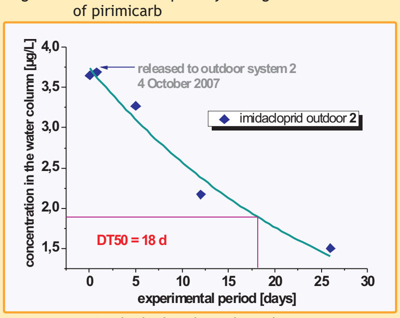

Figure 7: Microbial/photolytic degradation of imidacloprid

Conclusion

- Microbial degradation is low for both substances as compared to photodegradation
- Photodegradation was lower than expected from laboratory studies [3][4] although the streams were fully exposed to sunlight, and there was no turbidity.
- If a Dt50 < 1 d could be observed has to be checked in the future.
- In the field, biogenous and geogenic turbidity, the occurence of yellow substances and shading by canopy are common phenomena which have to be considered strong factors in further reducing photodegradation of substances.

Table 1: Parameters of the first order degradation curve fittings

Experiment	C_0 [µg/L]	k [day^{-1}]	DT50 [days]	Chi²/DoF	R^2
Pirimicarb ind. 1	0.9619	0.0143	49	0.00077	0.9843
Pirimicarb ind. 2	9.6388	0.0134	52	0.04082	0.9922
Pirimicarb outd.2	2.6825	0.0346	20	0.08284	0.9179
Imidacloprid ind. 1	9.7623	0.0093	75	0.0786	0.9646
Imidacloprid outd.1	4.8868	0.0321	22	0.0520	0.9847
Imidacloprid outd.2	3.7446	0.0376	18	0.03101	0.9756

References

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