The fate of urease inhibitors in two agricultural soils

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1. Introduction

Urease inhibitors (UI) are organic trace substances, which are applied along with urea fertilizers to reduce NH_3 emissions from agricultural fields. Due to the recent amendment to the German fertilizer act (DüngG) which now dictates the use of UI, increasing amounts of these substances will be applied to arable soils. So far, little is known about the fate of UI in soils and there is only few data on the leaching of UI from soil to groundwater, especially with respect to field data. The aim of this study was to investigate the fate of two different UI, i.e. N-(2-Nitrophenyl) phosphoric acid triamide (**2-NPT**) and N-(n-Butyl)thio-phosphoric triamide (**NBPT**) in two agricultural soils.

2. Research Questions

How long do UI remain in the topsoil following application?
Which portion will be translocated to deeper soil layers?

3. Material & Methods

Soil sample collection

- On two agriculturally used fields in northern Germany
- Both topsoils: loamy sands
- 2-NPT (as urea prills) or NBPT (as a mixture with urea solution) were applied along with urea
- Soil samples from 0-5 cm depth (topsoil) were taken -1, 1, 3, 6, 8, 10, 12, 14 and 21 days following the application
- In Addition: Soil samples from 5-15 cm and 15-30 cm depth on day -1 and 21

Table 1: Properties of the topsoil

soil	pH	C_{org} [%]	⌀ water content [%]
Berge	5.9	0.96	5.0
Ribbeck	7.6	1.39	7.2

Soil extraction and analysis

1. Field-moist samples were sieved to 2 mm
2. 20 ml extraction solution (50 Vol.-% Acetonitrile/50 Vol.-% H_20 for 2-NPT and 0.1 M KCl for NBPT) + 10 g soil
3. Horizontal shaker (30 min, 120 rpm)
4. Centrifugation (30 min, 3830 g)
5. Supernatant was filtered through cellulose acetate filters (0.45 µm)
6. Extracts were adjusted to neutral pH using dilute NaOH solution
7. Measurement of 2-NPT and NBPT by HPLC-MS

4. Results & Discussion

- 2-NPT (topsoil, day 1):353 ± 151 µg/kg (Berge); 302 ± 148 µg/kg (Ribbeck)
- 2-NPT was no longer detectable in the Ribbeck topsoil after 10 days (figure 1), 2-NPT decreased much slower in the Berge topsoil, reaching concentrations of 15.4 ± 15.7 µg/kg after 21 day (figure 2)
- NBPT was not found in any of the two soils
- None of the inhibitors could be detected in deeper soil layers
- No strong leaching of substances is assumed due to precipitation (< 9 mm/d)

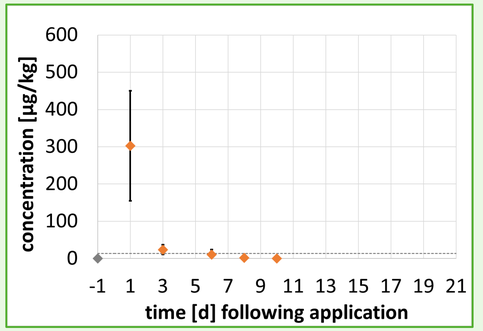

Figure 1: 2-NPT concentration in Ribbeck topsoil

- 2-NPT fate is related to different soil properties

→ remained shorter on Ribbeck than on Berge topsoil

→ Higher C_{org} content and soil moisture (table 1) in the Ribbeck topsoil may have led to better microbial activity and thus to faster degradation

→ hydrolysis seems less important than degradation, as this was slower in the Berge topsoil despite the acidic pH

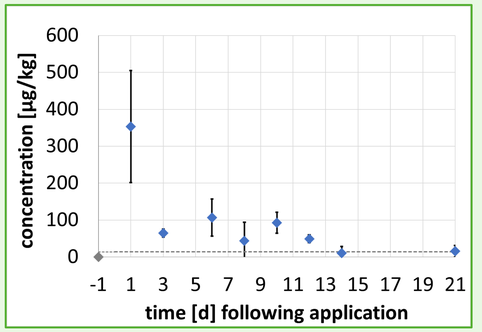

Figure 2: 2-NPT concentration in Berge topsoil

- NBPT was degraded very quickly in both soils

→ Rapid degradation due to a combination of hydrolysis and microbial degradation

→ Our results are consistent with those from the literature [1]

5. Conclusion

- 2-NPT is more persistent than NBPT, irrespective of the soil properties.
- The fate of 2-NPT was presumably governed by C_{org} content and soil moisture.
- Both substances have low persistence and are therefore not expected to leach into groundwater.

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[1] Engel, Richard E.; Towey, Brad D.; Gravens, Emily (2015): Degradation of the Urease Inhibitor NBPT as Affected by Soil pH. In: Soil Science Society of America Journal 79 (6), S. 1674–1683.