Effect of DOM quality and quantity on linuron degradation by a multi-species bacterial community in surface water

Benjamin Horemans, Philip Breugelmans, Erik Smolders, Johan Hofkens and Dirk Springael

Division of Soil and Water Management, Department of Earth and Environmental Sciences, Katholieke Universiteit Leuven, Kasteelpark Arenberg 20, B-3000 Leuven

Introduction

- Dissolved organic matter (DOM) is an important natural source of carbon, energy and nutrients for heterotrophic microbial communities in surface water.
- Quality and quantity of DOM are known to influence enzymatic activity, growth and composition of aquatic communities.
- Information on the effects of DOM on specific microbial functions like pesticide degradation in surface water is scarce.
- In this study, we examine whether degradation of the phenylurea herbicide linuron by a multi-species bacterial consortium is affected when exposed to (i) an increasing quantity of easy-degradable carbon, or (ii) DOM of natural origin with varying biodegradability in addition to linuron, under planktonic growth conditions. The consortium consists of 3 bacterial strains which mineralizes linuron through the synergistic interactions shown in Fig. 1. The effect of DOM on linuron degradation was studied in batch degradation experiments.

Materials and Methods

- The following batch degradation experiments were setup in vials containing minimal medium (MM) with 0.1 mM linuron:

i. with an increasing amount of citric acid (0.28 – 2.8 mM) as additional C source and inoculated with the linuron mineralizing triple-species bacterial consortium .

ii. with citric acid, leaf leachate and soil-derived DOM (0.4 and 1.6 mM DOC (dissolved organic carbon)) as additional C-source and inoculated with strain *Variovorax* sp. WDL1.

- Specific fluorescent labels were used to differentiate between strains (Breugelmans *et al.*, 2008) by means of epifluorescent microscopy.
- Concentrations of linuron and the metabolite 3,4-DCA were monitored using HPLC.

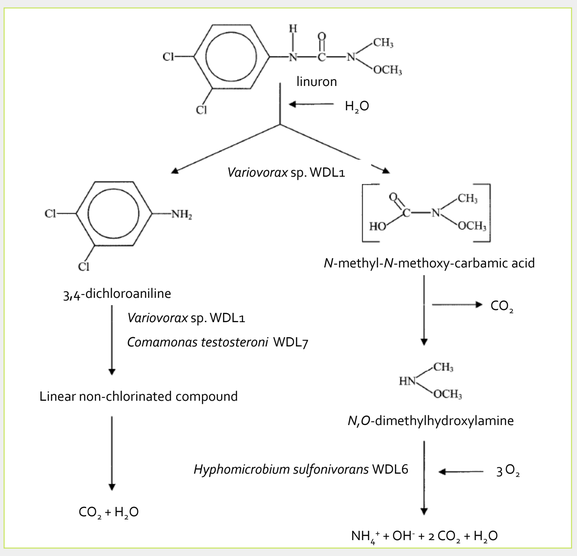

Fig.1: Synergistic interactions in the degradation of linuron between members of the triple species consortium used in this study (Dejonghe et al., 2000)

Results

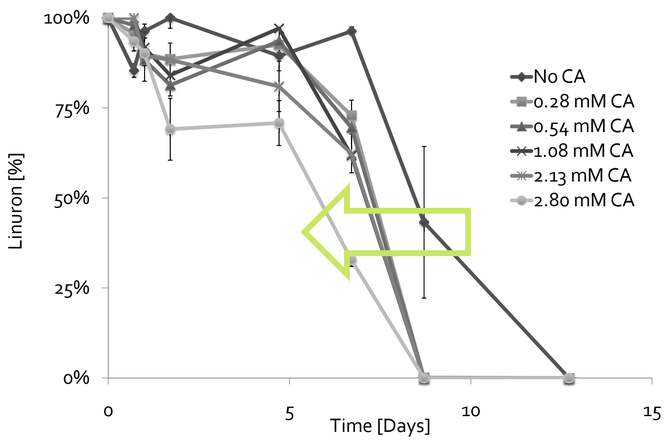

Fig.2: Linuron degradation (0.1 mM linuron) by the consortium in the presence of an increasing quantity of citric acid (CA) results in decreasing lagtime (see arrow).

i. An increasing amount of citric acid resulted in a decreasing lag phase (Fig. 2) of linuron degradation by the triple-species consortium and an increase in total biomass, mainly because of growth of the 3,4-DCA degrader *Comamonas* sp. WDL7 (data not shown).

ii. In cultures containing only *Variovorax* sp. WDL1 (Fig. 3):

- Presence of citric acid resulted in an increase in lag phase of linuron degradation and 3,4-DCA transiently accumulated till higher concentrations than in cultures without added citric acid.
- Leaf leachate resulted in an increased degradation rate, but more 3,4-DCA accumulated.
- Soil-derived DOM resulted in an increased linuron degradation rate and a decrease in DCA accumulation compared to the degradation of linuron in the absence of additional C-sources.

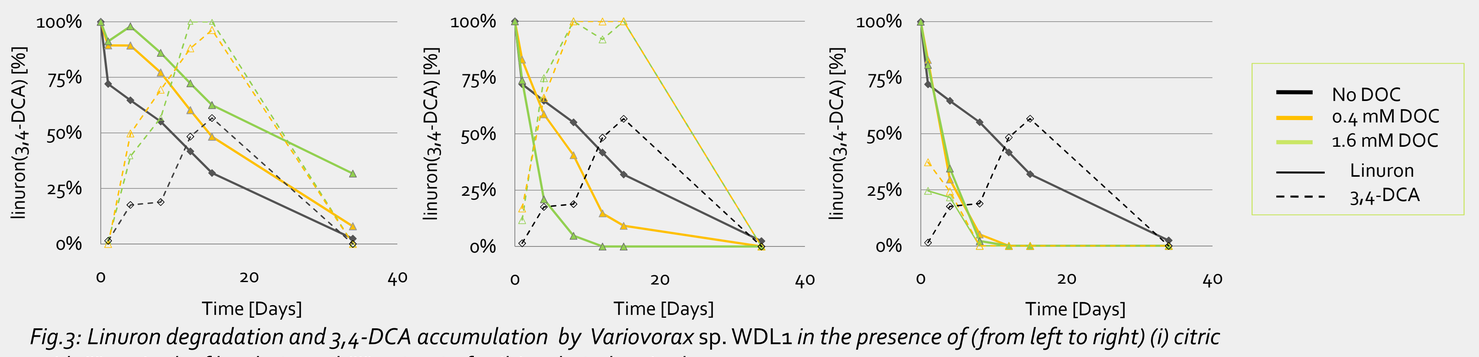

Fig.3: Linuron degradation and 3,4-DCA accumulation by Variovorax sp. WDL1 in the presence of (from left to right) (i) citric acid, (ii) maize leaf leachate and (iii) extract of soil-incubated maize leaves

Conclusions

- By stimulating the growth of the downstream linuron metabolite degrader *Comamonas* sp. WDL7, easy-degradable C-sources like citrate can stimulate overall linuron degradation under planktonic growth conditions.
- More complex and natural DOM stimulated linuron degradation by *Variovorax* sp. WDL1. In contrast, the presence of more easy-degradable DOM inhibits 3,4-DCA degradation resulting in a higher accumulation of the metabolite 3,4-DCA.
- Breugelmans *et al*. (2008) observed that when citrate was added to the consortium under sessile conditions linuron degradation decreased, indicating that the effect of additional C sources can even be opposite when considering planktonic and sessile conditions.

Breugelmans P, Barken KB, Tolker-Nielsen T, Hofkens J, Dejonghe W, Springael D (2008). Architecture and spatial organization of a triple-species bacterial biofilm degrading the phenylurea herbicide linuron. FEMS Microbiol. Ecol. 64: 271-282.
Dejonghe W, Berteloot E, Goris J, Boon N, Crul K, Maertens S, Hofte M, De Vos P, Verstraete W, Top EM (2003). Synergistic degradation of linuron by a bacterial consortium and isolation of a single linuron-degrading *Variovorax* strain. Appl. Environ. Microbiol. 69: 1532-1541.