Degradation and sorption in subsurface and aquifers of the herbicide metabolite BAM (2,6-dichlorobenzamide) after non-point contamination

***Gry S. Janniche, Liselotte Clausen, Bolette Nygaard, and Hans-Jørgen Albrechtsen**

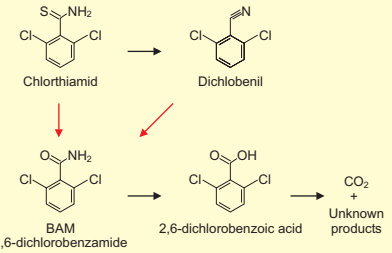
Institute of Environment & Resources, Technical University of Denmark, Bygningstorvet B115, DK-2800 Kgs. Lyngby, Denmark

**gsf@er.dtu.dk / www.er.dtu.dk*

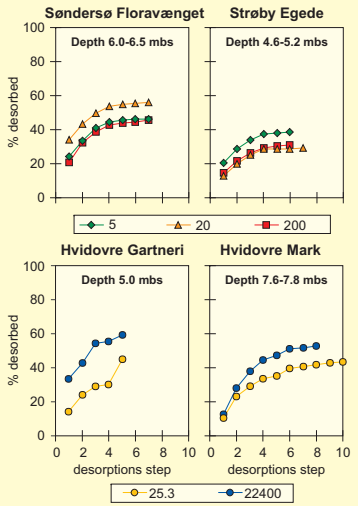
Background

The total weed control herbicide dichlobenil (e.g. Prefix and Casoron) is degraded to the metabolite dichlobenzamid (BAM), which is relatively persistent, and easily transported. Therefore BAM is often found in subsurface and aquifers, e.g. in Denmark, Sweden and Germany, where it is found in 20-44% of the investigated abstraction wells. It is still the most often found pesticide in Danish groundwater, nine years after it was abandoned in Denmark.

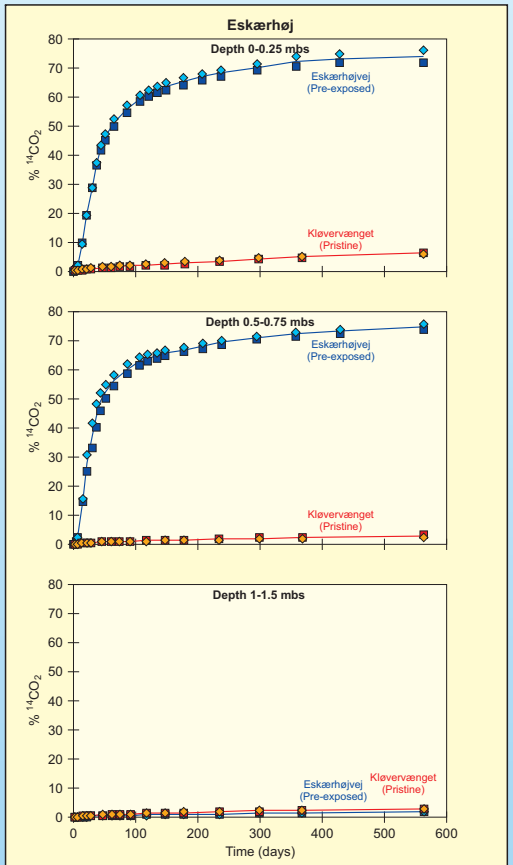
To get insight in the controlling parameters for the persistence of BAM the degradation and sorption of the metabolite BAM was investigated in soil, subsurface and aquifers.



Degradation pathways



The sorption of BAM is strong - and to some extent irreversible - in anaerobic sediments, which may function as sink. The figure shows the cumulated desorption (in percentage) as function of number of desorption steps after adsorption equilibrium was reached. Data from different initial concentrations (µg/L) at the start of the adsorption.



Effect of pre-exposure: sandy sediments with known history of pre-exposure were adapted and degraded BAM, whereas uncontaminated sediments did not. However, layer below 1 mbs under the pre-exposed site were not adapted. Initial koncentration: 100 µg/kg.

Methods

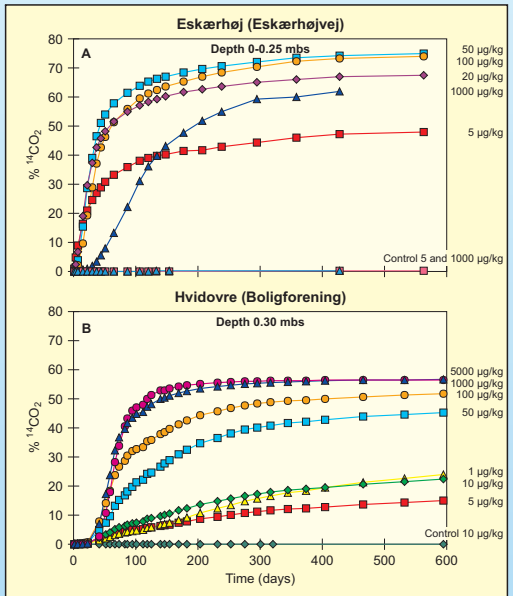
From 10 cores 58 samples were investigated, including topsoil, unsaturated zone and aquifers, clayey till and sandy sediments.

Aerobic degradation of ^{14}C-ring-labeled BAM, with collection of $^{14}CO_2$ in NaOH-traps included uncontaminated and contaminated sediments.

The metabolite 2,6-dichlorobenzoic acid was analysed for by GC-MS.

Sorption was measured by standard procedure with ^{14}C-BAM, 7 days of equilibration time and 5 g of sediment and 5 mL sterile filtered groundwater.

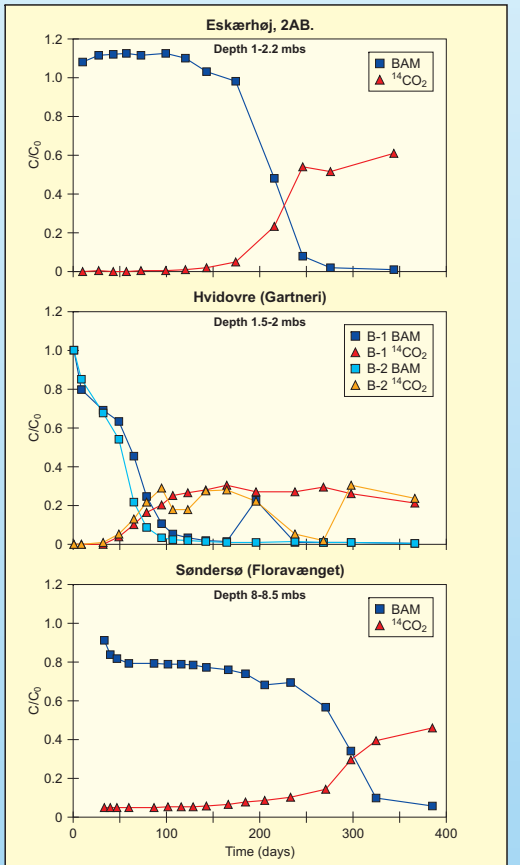
Desorption was measured after 3 days of equilibration after centrifugation and replacement of the water phase. This was repeated up to 8 times.



Effect of initial concentration in pre-exposed sediments. In clayey till (Hvidovre) the degradation rate increased with increased initial concentrations, indicating growth of the degrading population. In sandy sediments (Eskærhøj) BAM was degraded relatively fast at all concentrations.

Results

- BAM was microbially mineralised to CO_2 mainly in the upper meter below surface
- BAM was much easier degraded in contaminated sand (up to 200 µg/kg dichlobenil) than in uncontaminated sand. However, this effect of pre-exposure was not seen in clayey sediments
- Previous exposures have led to adaptation in sandy sediment in the upper meter below surface, but exposure alone did not prompt adaptation
- In contaminated clayey till sediments degradation rates increased with increasing BAM-concentrations in the range 1-5000 µg/kg, indicating growth-controlled kinetics
- In sediments from a contaminated sandy location, degradation rate was relatively high and independent of the initial concentration. This was probably due to higher numbers of specific degraders due to long exposure to dichlobenil and BAM
- 3 exposed aquifers showed BAM degradation at high initial concentrations (100 µg/L) in 4 out of 6 incubations. No degradation was observed in aquifer incubations with low initial concentrations (5 µg/L)
- 2,6-Dichlorobenzoic acid was verified as a metabolite in the pathway to CO_2, and its field detection may thus indicate BAM-degradation
- In reduced clayey till sediments, BAM was relatively strongly adsorbed, since more than 40% of BAM remained sorbed, and only desorbed very slowly



Removal of BAM due to degradation (production of $^{14}CO_2$) in 3 pre-exposed aquifers at initial concentraitons of 100 µg/L.

Conclusion

Despite degradable, the metabolite BAM remains quite persistent when it has reached the subsurface. Even though degradation in pre-exposed aquifers was seen, degradation only took place at high initial concentrations (100 µg/L) and not in all incubations (4 out of 6).

Acknowledgement

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References:

Ludvigsen, L., Clausen, L., Jørgensen, P.R., Hoffmann, M., Fredriksen, G.S., Nygaard, B., Albrechtsen, H.-J. & Jensen, T.F., 2005: Fate of BAM in aquifers (In Danish), Danish Environmental Agency, Copenhagen. Miljøprojekt, 1000. pp. 1-222.