Rapid degradation of pesticides at low concentrations - the possibility of using biodegradation to purify polluted groundwater during sand filtration

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Introduction
Contamination of groundwater with organic micropollutants like pesticides, solvents, and pharmaceuticals forces waterworks in many areas of the world to either close down abstraction wells or to purify the water before it is distributed. In Denmark, herbicides like the phenoxy acids, phenylureas and especially the degradation product of the herbicide dichlobenil; 2,6-dichlorobenzamide (BAM), have closed down numerous wells due to their presence above the 0.1 µg/L threshold limit. In recent years a number of microorganisms capable of degrading these classes of pesticides at relevant low concentrations have been isolated and described. This has led us to initiate studies on the possibilities of using these microorganisms to purify groundwater either at remediation wells or during simple biological water treatment at waterworks. The results presented here are preliminary results of an ongoing study on BAM-degradation during simple water treatment.

Methods
- BAM-degrading *Aminobacter* sp. MSH1 was isolated from soil (Sørensen et al. 2007).
- Lab-incubations with 14C-labelled BAM were performed to see if it was possible to obtain both degradation and complete mineralization to CO2 of low BAM concentrations.
- Laboratory column experiments were performed to mimic processes occurring in the rapid sand filters of waterworks. The following parameters were used: Residence time 25-60 minutes, temperature 10-20 °C, filter size 0.1-6 L, BAM conc. in spiked tap water ~2 µg/L, 10^7-10^8 bacteria added per gram of filter sand.
- A field scale experiment is currently running treating polluted groundwater and mimicking a typical waterworks using rapid sand filtration for simple water purification.

Results & Discussion
Batch experiments showed that *Aminobacter* sp. MSH1 can degrade and mineralize BAM in concentrations from less than 1 µg/L to 50 mg/L at temperatures from 10-25 °C. E.g. the incubation of a moderate number of cells (6*10^7 cells/mL) resulted in the complete degradation of 1 µg/L BAM in less than 0.5 hours at 10 °C (Fig. 1).

![Fig. 1. Results from a pure culture batch experiment with 1 µg/L BAM and 6*10^7 MSH1-cells / mL.](image-url)
The fact that the microorganism can degrade trace concentrations is vital if it is to be used to clean up groundwater with typical concentrations of 0.1-2 µg/L.

Column experiments were set up in the laboratory, to determine whether *Aminobacter* sp. MSH1 was capable of adhering to sand filter material and subsequently degrade BAM, and furthermore whether the activity could be kept for a prolonged period of time. The bacterial strain was found to adhere well to various filter materials (Albers et al. 2013) and complete degradation of ~2 µg/L BAM was obtained at 20°C and 60 minutes residence time in small (0.1 L) sand filters, while 60-70% degradation was obtained in larger (6 L) filters at more realistic temperature (10°C) and residence time (25 min), where in addition backwashing was applied (Fig. 2). On the other hand, the stability of the larger columns was much better.

A field scale experiment was set up in order to test the degradation of BAM in a pilot waterworks, operating like a typical Danish waterworks with polluted groundwater (0.15 µg/L BAM) as the source water. The experiment was started only recently, but initial results indicate good degradation of BAM just after inoculation with bacteria, but also that the degradation is lost within 1 month. Analysis of various microbial parameters will hopefully reveal the reason for the loss of degradation and show the way to a more stable system.

References
