THE ROLE OF MICROBIAL HETEROGENEITY IN PESTICIDE DEGRADATION IN AGRICULTURAL SOILS

Philip Binning, Technical University of Denmark (DTU), +45 4525 2161, pjbi@env.dtu.dk

1. Annette E. Rosenbom, Geological Survey of Denmark and Greenland
2. Anders R. Johnsen, Jens Aamand, Geological Survey of Denmark and Greenland
3. Arnaud Dechesne, Barth Smets, Technical University of Denmark
4. Nora Badawi, Geological Survey of Denmark and Greenland
5. Philip Binning, Technical University of Denmark

Many pesticides are found in deeper groundwater reservoirs despite being biodegradable. One explanation could be that soils and the microbial populations in them are heterogeneous, and that fast pathways with low degradation rates are responsible for pesticide breakthrough to deeper groundwater systems. This paper aims to use new detailed observations of the spatial variability of microbial populations in soils and models to explain observed pesticide concentrations in deeper groundwater.

Field work was conducted to measure the spatial distribution of microbial degraders of the phenoxy acid herbicides MCPA and 2,4-D at a centimeter scale at an agricultural site in Denmark. At the site, soil degradation rates were measured at seven depths over a one meter interval using a microplate mineralization assay with 96 wells covering total area of 6.5x10cm. Each well provided a dataset recording the amount of herbicide mineralization as a function of time. This data was analysed by fitting either a Monod kinetic model coupling degradation rates of the herbicide to microbial population growth, or a simple zeroth order model. A consistent set of Monod kinetic parameters was found to describe the datasets, with the only parameter varying between sample locations being the initial microbial population size. The largest microbial populations and highest degradation rates were observed in the upper soil layers.

The fitted kinetic models were incorporated into a 3D contaminant transport model to describe herbicide movement through the soil. The transport model included advection, dispersion, sorption, degradation and diffusion processes. Water flow rates were provided by a calibrated Richards equation model driven by an observed rainfall time series and employing measured soil parameters. The hydraulic model was calibrated to field observations at the site. Both the transport and hydraulic equations were solved using Multiphysics, a generic partial differential equation solver.

Results show that the breakthrough concentration of the pesticides depends greatly on the character of the soil heterogeneity. When mild heterogeneity is modeled, breakthrough concentrations are similar to those of a homogeneous soil. However, when soil macropores are considered, much higher breakthrough concentrations are obtained than for the homogeneous model. Finally, the model can be used to show that it is important to consider whether microbially active zones are located together with hydraulically fast pathways. Such coupling has a great impact on the expected pesticide breakthrough.