# Transient Dissolved Organic Carbon Transport Through Soils


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## Introduction

Dissolved organic carbon (DOC) is an important constituent of soil solution that plays a role in many chemical and biological processes in soils; it is also an important energy source for bacteria in the soil ecosystem.

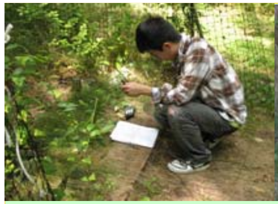
Previous studies revealed that soil properties, hydrologic influences, soil moisture significantly control the transport and fate of dissolved organic carbon in the soil. Moreover, DOC concentration is reported varies along different soil depth, it is usually found decreased with depth in soils. The mechanisms that affect DOC transport in are not well understood. In particular, dynamic information on DOC transport through forest soils on short time scales (one or two precipitation event) is lacking at present.

DOC is a very complex mix of organic compounds. A key to quantifying DOC dynamics is to establish useful approximations for behavior of this complex mixture. Biodegradable dissolved organic carbon (BDOC) is an important part of DOC. It is reported that between 12 and 44% of DOC released from the forest floor can be decomposed in solutions by indigenous microbes. As an important part of DOC, the transport processes of BDOC in soil have not yet been extensively reported.

## Questions

➢How do the DOC and BDOC transport through soils under the regulation of transient soil water flux?

➢How do DOC, BDOC and flow interact in soil columns on short time scale (one or two precipitation events)? Can the model successfully predict the DOC and BDOC transport mechanism in the forest soil?



## Methods

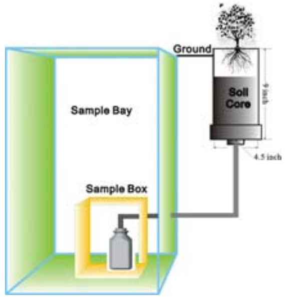
In our study, observation data was used to guide model development.

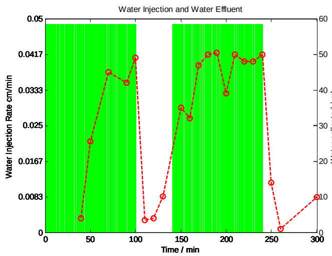
➢In-situ soil core was installed under a mixed deciduous canopy.
➢Dripping "artificial rain"on the top of soil cores, sampling the water collected at the bottom of the cores for DOC and BDOC.
➢Plug-flow biofilm reactors was used to measure the BDOC concentration.
➢Developed a series of physically based models to describe the water and DOC, BDOC dynamic process.
➢Calibrated and optimized model using inverse technique (UCODE).

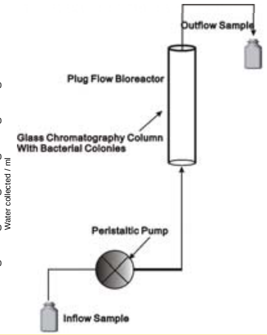
## Experiments

Field Experiments:
➢Used TDR to obtain an estimation of the initial soil moisture.
➢Applied Bromide-amended solution on the top of in-situ soil core at a controlled speed.
➢Impose a rest period between two flush of "rain"
➢ Collected water sample at the bottom at a fixed time interval.
➢Kept track the temperature at the top of the soil core and 3 cm into the soil core.

Lab experiments:
➢Plug-flow biofilm reactor was used to separate BDOC and non-BDOC.

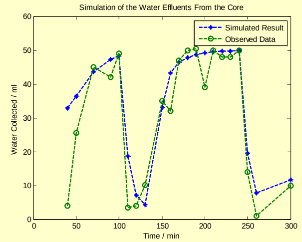


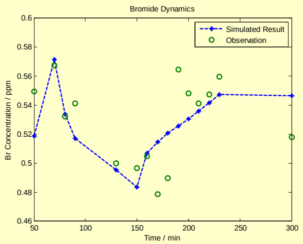



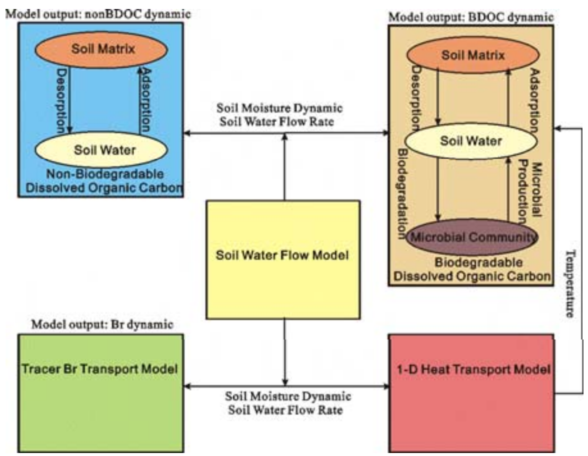

## Simulation Results-soil water & Br

➢The effluent of the water is a double peak curve as time continues.
➢Bromide tracer analysis results and field data show that the initial soil moisture is very small .




## Model Structure



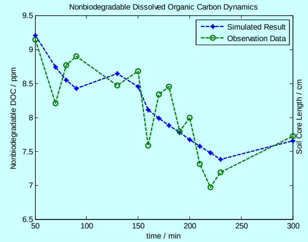

## Model Description

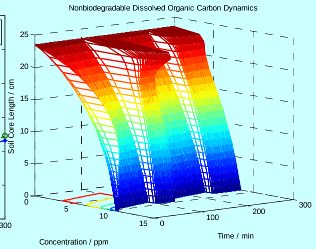
➢Soil Water Flow Model:
The one-dimensional Richards' equation with a root uptake sink term is used to describe the soil water moisture dynamic through the in-situ soil columns. Soil moisture and water flux as outputs is used by the rest of the models.

➢Heat Transport Model:
Neglecting the effect of water vapor diffusion on transport, one-dimensional heat transfer can be described with a convection-dispersion type equation, the temperature dynamic output from this model is used by the BDOC model.

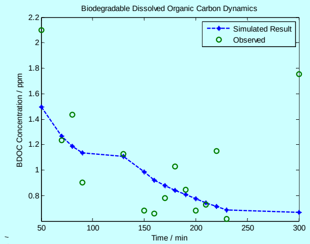
➢Reactive Transport Model:
❖DOC transport are described by one-dimensional convection-dispersion equation (CVE) with non-equilibrium adsorption term.
❖CVE together with a first order biodegradation term and zero order microbial production term is adopted for BDOC transport.
❖CVE is also used for Tracer Bromide dynamics. This model can help to calibrate the flow model

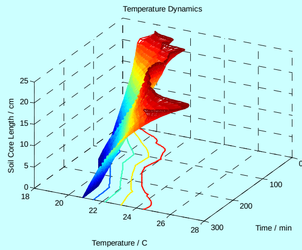
## Simulation Results-Dissolved Organic Carbon




➢The experiment data shows a major decline trend for both DOC and BDOC. The model follows the same pattern as the data.
➢Top boundary: Dirichlet boundary; Lower boundary: Neuman boundary.
➢The correlation coefficient between simulated results and data for nonbiodegradable DOC is 83.4%, for BDOC is 52.7%




## Heat transfer

➢The temperature on the top of the soil core increased throughout the experiment.
➢The top boundary condition was used as the Dirichlet boundary
➢Model calibration results reveal the model's ability to depict the temperature dynamic in the core.

## Discussion

➢The simulation results show that the model can match the main features of the observed DOC and BDOC patterns under transient soil water flux conditions. However, the data show a more complex pattern along with the major trend, the model is incapable to match those.

➢UCODE calibration shows that dispersivity for both Br model and DOC model is around 1.5 m, which is higher than the normal value. This might caused by high local variations in the pore water velocity.

## Future Research

I. Additional processes (e.g. bacterial growth) will have to be incorporated to achieve an appropriate degree of realism.

II. Other model approaches: Stochastic approach transfer function approach might be adopted to compare with the current research.

III. Extend the model to higher dimension and larger spatial scale