Carbon and nitrogen dynamics in a soil profile: Model insights and application to a restored Swiss riparian area

A. Brovelli¹, J. Batlle-Aguilar¹, J. Luster², J. Shrestha², B. Hubeer², P. Niklaus³, D.A. Barry¹

¹ Ecological Engineering Laboratory, EPF Lausanne (Switzerland) alessandro.brovelli@epfl.ch, jordi.batlle@epfl.ch, andrew.barry@epfl.ch
² Soil Structure and Function Group, Swiss Federal Research Institute (WSL), Birmensdorf, Switzerland joerg.luster@wsl.ch, juna.shrestha@wsl.ch, benjamin.huber@wsl.ch
³ Institute of Grassland Sciences, Swiss Federal Institute of Technology (ETH), Zürich, Switzerland pascal.niklaus@ethz.ch

1. Research aims

• Monitor and understand changes of ecosystem functioning in riparian areas undergoing restoration
• Simulate the transport and distribution of soil organic matter (C and N) in a soil profile
• Evaluate how these processes are modified after land use change (or revitalization)

2. Field site description

• North East Switzerland, Thur River corridor
• A revitalization project, involving removal of levees and foreland, has been implemented to create more natural conditions in the riparian zone
• Different functional processing zones (FPZ) in non-restored and restored sections (see poster A46, by Luster et al.) are intensively monitored
• At present, the model was applied to a single monitoring point (F2)
• Mixed deciduous forest, a FPZ with partly restored hydrological behaviour

3. Soil properties monitoring

From October 2008 to October 2009:
• Volumetric soil water content and temperature at several depths. 30 min. resolution in time
• Soil solution sampled at several depths on a regular basis, more often during a pulse-flood in July
• Solutions analysed for dissolved organic C, nitrate, ammonium, dissolved organic N, other major inorganic anions and metals
• Topsoil samples collected at the same dates as the soil solution and analysed for denitrification enzyme activity, potential nitrification and related properties
• Soil respiration and N₂O emissions were also measured at each sampling event

4. Soil C and N turnover model

Model development is described in details in an oral presentation (Batlle-Aguilar et al.) scheduled on 5th Wednesday 2010, 15:45-16:00, Room 33, Session HS3.1 (Brovelli et al., in preparation)

• The model is an evolution of the zero-dimensional mechanistic batch model of Porporato et al. (Adv. Water Res., 26: 56-58, 2003)
• The soil profile is subdivided into 4 functional units (or compartments)
• Evapotranspiration and plant uptake processes only active in the two shallower compartments
• Soil compartments 1 to 3 are variably saturated
• The 4th compartment remains always fully saturated (regional aquifer)
• Water movement and solute transport is based on mass balance equations (infiltration/leakage/evapotranspiration)
• Microbial decomposition of the soil organic matter (SOM) drives biogeochemical transformations of C and N
• The activity of the soil biota is primarily controlled by the soil moisture content

5. Preliminary results

Model inputs: Rainfall recorded at the experimental site and soil physical properties measured at the F2 monitoring point

• Monitored soil water content and nutrient concentrations are reasonably well reproduced by the model. Nutrient concentrations are on the same order of magnitude, and the measured and predicted trends are compatible
• Gas efflux (i.e., CO₂), a very representative parameter of the soil ecosystem dynamics, is well represented by the model
• Preliminary results obtained with the new model are encouraging. We will keep investigating nutrient dynamics transport in the vertical soil profile, also using additional sampling locations.