Transport and Sequestration of Organic C in Contrasting Soils Amended with C-14 Enriched Leaf Litter

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The Event

The 1999 14C Event

- 14C-labeled material was applied to both enriched and background plots.

Record of the 14C-Pulse in Tree Rings

- The 14C signatures in the local tree ring record demonstrate the unique and unprecedented nature of the 1999 event.

14C in 2000 Vegetation Samples

- 14C in 2000 foliage suggested that the ecosystem signature could be exploited for carbon cycle studies.

Objectives

Use enriched litter as a well-defined source to quantify organic C flux through soil profiles as a function of storm events.

Quantify the impact of coupled hydrological and geochemical processes on the fate and transport of dissolved organic C through contrasting soil profiles being used in the Enriched Background Isotope Study at ORNL.

Quantify the mechanisms that control enhanced carbon accumulation within deep subsols of forested Ultisols and Inceptisols.

The Approach

- Excluding indigenous litter and applying enriched or background litter

- Eight plots were established at each site. Half receive enriched litter each year and the other half receive background litter. Ambient litterfall is excluded from all plots (see photo).

Two Soil Types are Being Studied (Two Inceptisols / Two Ultisols)

- Two background and two enriched plots from each of the four EBS sites (16 plots) were instrumented with four tension lysimeters and four tension-free lysimeters. Two of each type were placed within the A- and B-horizons of the soil profiles.

Multi-porosity sampling capabilities

- ZirChlo tension solution sampler for monitoring macropores and micropores domains.

- High tension solution sampler for monitoring micropores domains.

- Besides the addition of enriched and background litter, an aqueous nonradioactive Br tracer was evenly applied over each of the instrumented areas using a backpack sprayer. Non-radioactive Br tracer provides useful data for quantifying flow and transport processes at the various sites.

- Solution samplers were monitored during all storm events and analyzed for Be, TOC, and inorganic anions. Solution samples were analyzed for 14C.

- Bulk soil samples from each plot were characterized for select physical and chemical properties and organic C sequestration isomers were quantified for each subsol.

The Results

Carbon sequestration in Ultisol soil profiles

- Soil samples from lower B-horizons have significantly larger carbon sequestration capacities relative to upper A, E, A/E, and B/E horizons.

- Low organic C sequestration is usually associated with high Fe-oxide content.

Example of storm driven Br breakthrough in soil profiles

- Example storm driven DOC concentrations in soil profiles

- DOC concentrations and flux higher for A-horizons relative to B-horizons.

- Haw Ridge (party Inceptisol) has higher C flux which is consistent with its more rapid flow and transport characteristics and lower organic C retention capacity.

- Organic C fluxes at site are consistent with the hydrodynamics and geochemical retention capacities of the soils.

14C signatures in select pore water from Inceptisol and Ultisol soil profiles

- Enriched plots have higher 14C signatures in pore water than background plots.

- Pore water from Haw Ridge has a higher 14C signature relative to Walker Branch which is consistent with the more rapid flow and transport characteristics and lower organic C retention capacity at HB.

- Pore water from HB has a lower 14C signature relative to HB with B-horizons samples showing an increase of retention. This may be related to the higher organic C retention capacity of HB.

Conclusions

- Non-radioactive Br tracer provides useful data for quantifying flow and transport processes at the various sites.

- Organic C fluxes at each site are consistent with the hydrodynamics and geochemical retention capacities of the soils.

- Organic C sequestration is strongly correlated with the soil-fractional content.

- Pore water 14C signatures look promising. Enriched plots show higher values than background plots, and the data is consistent with the hydrological and geochemical characteristics.