Characterizations of Dissolved Organic Matter in Silvopasture, Pasture, and Forest Leachates

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INTRODUCTION

Silvopastoral agroforestry systems are being investigated for potential production and environmental benefits on complicated landscapes common to the Appalachian region. Cycling of organic carbon in forested and agricultural landscapes is gaining in importance as we try to understand land use impacts on global carbon cycling. Understanding the effects of land use management systems on carbon cycling is essential for understanding the potentials of such systems for storing carbon. Field and model studies indicate that hydrologic and DOC fluxes are closely coupled. The purpose of this study was to characterize dissolved organic matter leaching to the soil/bedrock interface in pasture, forest and silvopastoral systems.

STUDY AREA AND METHODS

The study site is located in southern West Virginia at 37° 47' 39" N, 80° 58' 22" W (Figure 1). The conventional pasture is primarily composed of orchard grass (*Dactylis glomerata* L.), Kentucky bluegrass (*Poa pratensis*), and white clover (*Trifolium alba*) and has been maintained as pasture for many years. The conventional pasture is surrounded by mixed hardwood forest, part of which was converted to silvopasture by thinning the primarily red oaks (*Quercus* sp.) and planting orchard grass, rye grass (*Lolium perenne* L.), and white clover. Four piezometers were installed to the soil/bedrock interface in each land use category (pasture, silvopasture, and forest). The pasture and silvopasture areas were rotationally grazed by sheep during the growing season. The lowest 30 cm of each piezometer was screened.

The piezometers were sampled immediately after each storm. The samples were filtered (0.45 µm) and analyzed for dissolved inorganic N (DIN) by suppressed ion chromatography and for total dissolved carbon (TC), dissolved organic carbon (DOC), and total dissolved N (TN) on a total organic carbon analyzer. Total dissolved inorganic carbon (DIC) was calculated as the difference between TC and DC. Total dissolved organic N (DON) was determined as the difference between TN and DIN. The filtered water samples were also analyzed on a scanning spectrofluorophotometer to construct excitation/emission matrices (EEM) of sample fluorescence intensities. The scans were constructed at 2 nm wavelength intervals in the excitation range 220 to 585 nm and emission range 235 to 600 nm. Peak fluorescence intensities were recorded for each of five organic groupings (tyrosine-like, tryptophan-like, protein-like, fulvic-like, and humic-like).

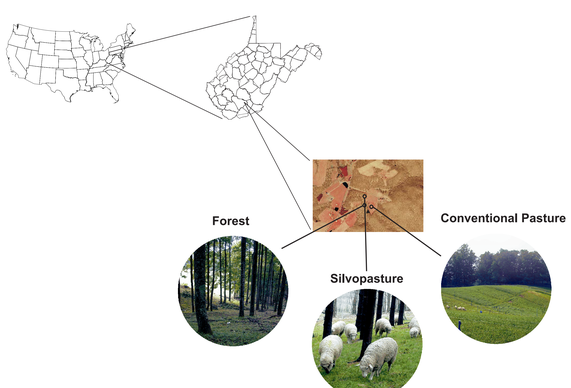

Figure 1. Study area.

RESULTS

Table 1 lists the mean concentrations of TC, DOC, DIC, TN, DIN and DON for the three land use types. Analysis of variance failed to show any significant differences ($P < 0.1$) in mean TC, DOC, DIC, DIN, or TN between land uses. There were significant differences in mean DON between forest and pasture land uses. Leachate in the pasture had the highest DIN concentration (3.9 mg L^{-1}) and the lowest DON concentration (0.5 mg L^{-1}).

The mean EEMs (Figure 2) for each of the three land uses showed differences in fluorescence properties. Mean peak fluorescence intensities were greatest in silvopasture for protein-like, fulvic-like and humic-like compounds (Fig. 3). Mean peak fluorescence intensity for tyrosine-like compounds was greatest in pasture leachates. No differences in mean peak fluorescence intensities were observed for tryptophan-like compounds.

Table 1. Mean concentrations (mg L^{-1}) total dissolved C (TC), dissolved organic C (DIC), dissolved inorganic C (DIC), total dissolved N (TN), dissolved inorganic N (DIN), and dissolved organic N (DON) for the three land uses. Standard deviations are shown in parentheses.

C or N parameter	Pasture	Silvopasture	Forest
TC	33.3 (30.81)	36.1 (21.89)	33.8 (27.10)
DOC	12.4 (13.25)	14.6 (14.07)	19.1 (23.37)
DIC	20.9 (26.20)	22.0 (14.51)	14.7 (13.31)
TN	4.4 (2.90)	3.4 (4.05)	3.0 (4.09)
DIN	3.9 (3.04)	2.2 (3.36)	1.6 (2.35)
DON	0.5 (0.77)	1.2 (0.93)	1.4 (1.76)

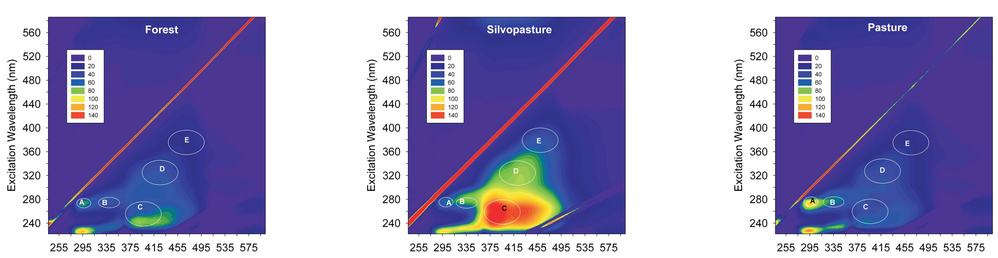

Figure 2. Mean excitation/emission fluorescence spectra for the forest, silvopasture, and pasture leachates. Group designations: A = tyrosine-like; B = tryptophan-like; C = protein-like; D = fulvic-like; E = humic-like.

DISCUSSION

Although no statistical differences were observed in leachate concentrations of TC, DIC, or DOC between the three land uses the fluorescence character of the leachates from silvopasture were different from those of pasture and forest. Previous study showed that rainfall was percolating to the soil/bedrock interface more frequently and in greater volume in the silvopasture than the pasture or forest sites. The difference was presumably a result of macropore flow, coupled with an organic layer disturbed by animal grazing. Surface particles, such as fecal bacteria, were appearing in leachate at the soil/bedrock interface in greater densities in the silvopasture than in the forest or pasture.

The pasture area was presumed to not have as dense a network of large macropores as the forest or silvopasture areas since trees and tree roots have not been present in that area for many years. The forest area responded infrequently and with low leachate volumes at the soil/bedrock interface, presumably because of the thick organic layer and shingling effect of recently fallen leaves. The differences in fluorescent properties of TC reaching the soil/bedrock interface are probably a result of the hydrologic response, amount of water interaction with surface organic and soil layers, and character of organic matter in the surface organic and soil layers. Further testing with parallel factor analysis might provide more information about the interactions of water and organic materials in the different land uses. Understanding the interactions between the hydrologic and carbon cycles in the different land uses will enhance our opportunities to maximize soil carbon sequestration. Carbon sequestration in agroforestry systems has already been identified as a promising ecosystem function and research such as reported here will provide the knowledge that enhances our opportunities to develop management practices that maximize ecosystem functioning goals.

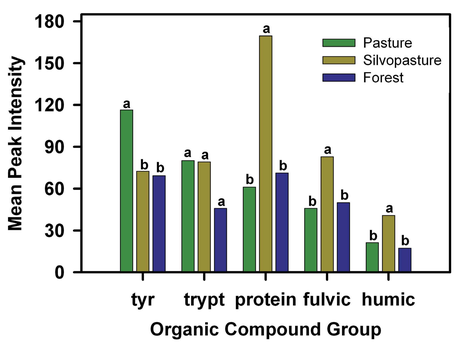

Figure 3. Mean peak fluorescence intensities for tyrosine-like (tyr), tryptophan-like (trypt), protein-like, fulvic-like, and humic-like compounds in the three land use leachates. Bars with the same letter, in a group, are not significantly different ($P < 0.1$).

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