Internal and external fluxes of dissolved organic carbon in forested headwater Amazonian catchments:
Near-surface and aboveground controls on DOC exports

Abstract 36.15-P

ND11

Mark S. Johnson[1*], Johannes Lehmann[1], Eduardo Guimarães Couto[2], Susan Riha[1], Mara Abdo[2], Evandro Carlos Selva[2], João Paulo Novaes Filho[2], Erick C.M. Fernandes[1]

[1]Dept. of Crop and Soil Sciences, Cornell University, USA, [2]Federal University of Mato Grosso (UFMT), Cuiabá, Brazil

*Email address: msj8@cornell.edu

Abstract

Dissolved organic carbon (DOC) concentrations were determined for throughfall, surface runoff, leaching water, groundwater seeps, and stream water during base and storm flows in four headwater catchments in an undisturbed forest near Juruena, Mato Grosso in the seasonally dry, southern Amazon. During the rainy season (Sep 03 – April 04), DOC concentrations in surface runoff (e.g., overland flow) were found to decrease from 53.8 ± 18.1 mg L^{-1} at the beginning of the rainy season to 9.4 ± 3.3 mg L^{-1} by the end of the rainy season (avg. value of all watersheds ± 1 std. dev.). Throughfall concentrations also decreased during this period from 16.3 ± 1.0 to 5.6 ± 1.1 mg L^{-1}. Stream flow DOC concentrations from weekly grab-samples of the four streams decreased over the period of study from 4.43 ± 1.45 to 0.74 ± 0.20 mg L^{-1}. Groundwater seep DOC concentrations were found to be relatively constant averaging 0.7 mg L^{-1}.

The seasonality of these forests appears to be the driving factor resulting in the temporal variability of DOC concentrations observed. Aqueous extraction of DOC from litterfall and new leaf growth following the first rains supplies fresh DOC to streams via throughfall and surface runoff, while DOC in infiltrating water is subjected to sorption and mineralization within the soil profile. DOC in leachate decreased in concentration from about 8 mg L^{-1} at 10 cm depth to concentrations of about 0.7 mg L^{-1} in emergent groundwater.

Storm flow was sampled at discharges approximately 5 times and 10 time base flow discharges. DOC concentrations in storm flow samples were consistently higher than base flow, with DOC concentrations on average five times higher than base flow. Considering the differences between DOC values for base flow and storm flow in light of the tremendous differences between DOC in surface runoff and groundwater indicates an important coupling of surficial processes with exports of DOC from headwater catchments.

Results and Discussion

Carbon inputs from the tree canopy to the forest floor are an important driver of C fluxes within and out of forests. Carbon in litterfall is leached out as DOC by surface runoff (Fig. 1) and infiltrating water. DOC in leachate at 10 cm and in emergent groundwater were found to be strikingly different (8.4 ±2.7 mg L^{-1} vs. 0.7 ±0.5 mg L^{-1}), but did not show a seasonal pattern. Cumulative litterfall-C inputs to the forest floor were 23X greater than DOC inputs (via throughfall) during the period of study.

DOC concentrations in throughfall (TF) and surface runoff (SRO) are strongly related (r^2 =0.65, p=0.03), and exhibit a seasonal pattern (Fig. 2). Storm flow and base flow DOC concentrations track the seasonal trend of aboveground DOC concentrations (Fig. 2), with strong relationships found between SRO and baseflow (r^2 =0.94, p<0.001), TF and base flow (r^2 =0.62, p=0.04), and SRO and storm flow (r^2 =0.67, p=0.02).

Discharge was found to be inversely related to all component DOC concentrations. This led to a decrease in DOC export late in the rainy season, even as discharge remained high (Fig. 3 and Table 1), demonstrating the coupling between aboveground processes and watershed DOC exports.

Figure 1. Carbon dynamics at the forest floor

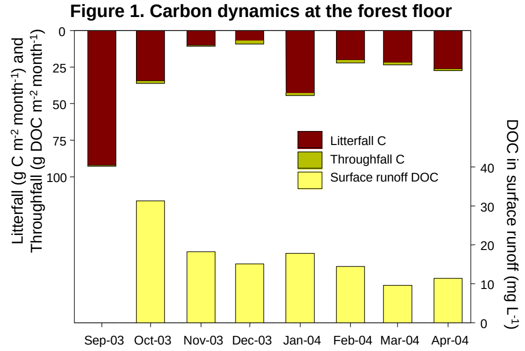


Figure 2. DOC concentrations in forested watersheds

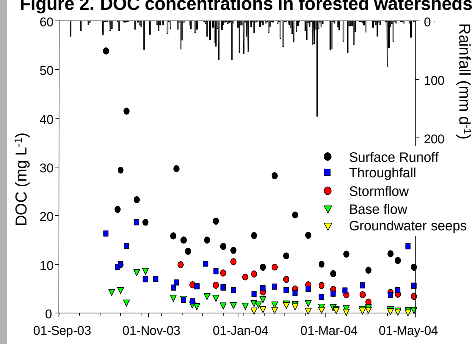


Figure 3. Rainfall-discharge-DOC flux relationship.

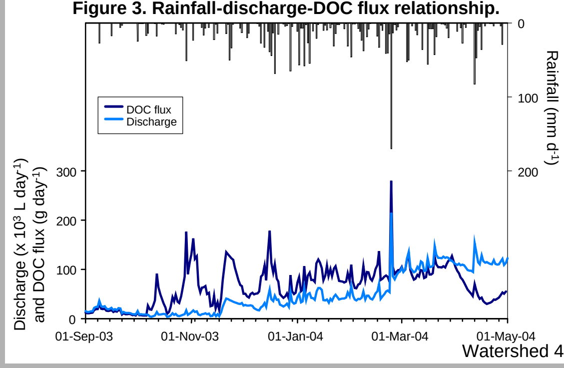
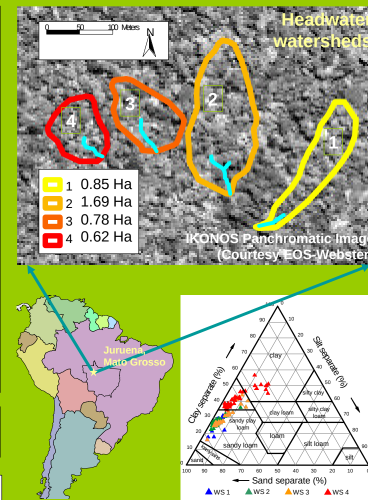


Table 1. Monthly Fluxes from Watershed 4- Discharge and DOC Exports

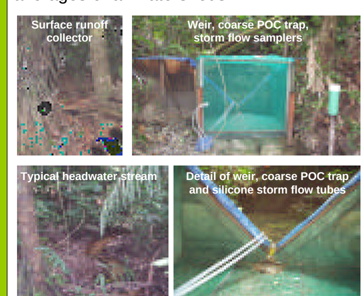
Month	Discharge (L x10^3)	DOC flux (g)
Sep-03	530	427
Oct-03	257	1289
Nov-03	583	2404
Dec-03	953	2162
Jan-04	1387	2699
Feb-04	1762	2758
Mar-04	3513	3161
Apr-04	3381	1628

Study Site and Methods



Surface soil (0-20 cm) textural classes by watershed (WS)

In each watershed, stream discharge is monitored continuously at a V-notch weir instrumented with a pressure transducer and data logger. A suite of tipping buckets has been installed in each watershed to measure timings of throughfall, overland flow, and percolating water in each watershed. DOC samples are filtered (GF/F glass fiber filters, 0.7 µm), treated ($HgCl$) and stored at 3°C until analysis. DOC is determined chromatographically after combustion. Statistics reported are monthly averages of all watersheds.



Conclusions

Carbon inputs to the forest floor correspond to higher DOC concentrations in surface runoff and streamflow. Solid carbon inputs from litterfall (g m^{-2}) are an order of magnitude greater than DOC inputs in throughfall (g m^{-2}). All surface DOC concentrations (throughfall, surface runoff, storm flow and base flow) were found to decrease during the rainy season, leading to a seasonal pattern in DOC export from watersheds. No seasonal trend in subsurface DOC concentrations (leachate and saturated zone groundwater) was detected.

The authors are grateful to Rohden Indústria Lígnea Ltda. for site access and support, for the field work of Benedito Silveira de Andrade and Elielton Anterio da Souza, and thank Jeff Richey and Alex Krusche for conceptual and logistical support.