Isotopic Composition and sources of Organic Carbon Pools within the Tana River Basin, (Kenya).

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Introduction

- Rivers play an important role in the global carbon cycle, and process ~1.9 Pg C annually (Cole et al., 2007). Rivers do not merely transport carbon from the terrestrial to the oceanic environment, but also bury and process organic matter, typically acting as a source of CO_2 to the atmosphere (Cole and Caraco 2001, Mayorga et al,. 2005).
- It is critical to understand carbon cycling both on a global and a watershed scale. However, there are few studies which quantify carbon fluxes in tropical rivers, and data for the African continent are particularly scarce.
- In this study, we report the altitudinal and seasonal patterns in carbon pools and their stable isotope compositions in Tana River Basin (Kenya)

Site and Methods

- The Tana River is the longest river system in Kenya (~1300 km), with a catchment area of ~130,000 km^2 (Kitheka et al., 2005).
- The main perennial source areas of the river are Mount Kenya (up to 5199 m asl), the Abardares ranges in the central highlands of Kenya, and the Nyambene Hills in eastern Kenya.
- The basin in general experiences a bimodal rainfall pattern: long rains between March and May and short rains between October and December.
- Data from field campaigns throughout the river basin are presented from three campaigns in February 2008 (Bouillon et al., 2009; dry-season), September to November 2009 (wet-season) and June-July 2010 (end-of-wet-season).
- Furthermore, monthly sampling was initiated in January 2009 at several locations (ongoing), and data up to March 2010 are presented here for 2 of the downstream sites (Garissa and Tana River Primate Reserve). Extensive flood plains are located between these 2 locations, flooding is irregular due to regulation of river flows by reservoirs upstream.
- The samples for total suspended matter (TSM) were filtered through pre-combusted and pre-weighed, 47-mm-diameter Whatman GF/F filters, dried and re-weighed, while samples for POC and δ^{13}C-POC were filtered on pre-combusted 25 mm Whatman GF/F filters, acidified, dried and packed in Ag cups. Soil and sediments samples were collected from all sampling sites, subsamples grounded, decarbonated and similarly packed in Ag cups. POC, δ^{13}C-POC, soil and sediments were measured with standard techniques (EA-IRMS). DOC and δ^{13}C-DOC samples were measured with a TOC analyzer coupled to a Thermo DeltaPlus IRMS.

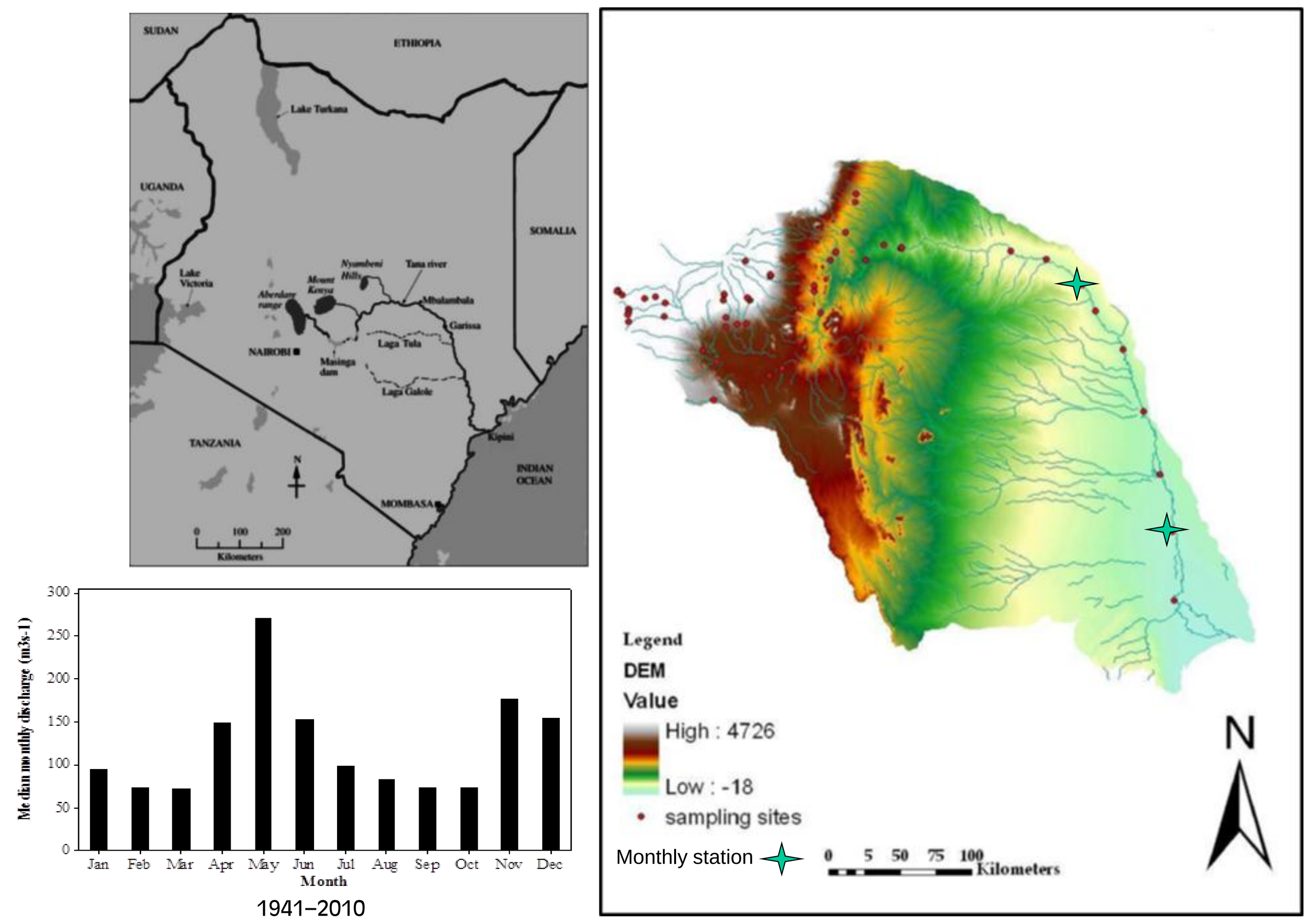

Figure 1: Location of the Tana River basin , sampling locations and monthly discharge.

Results & Discussion

Total suspended matter and particulate organic Carbon

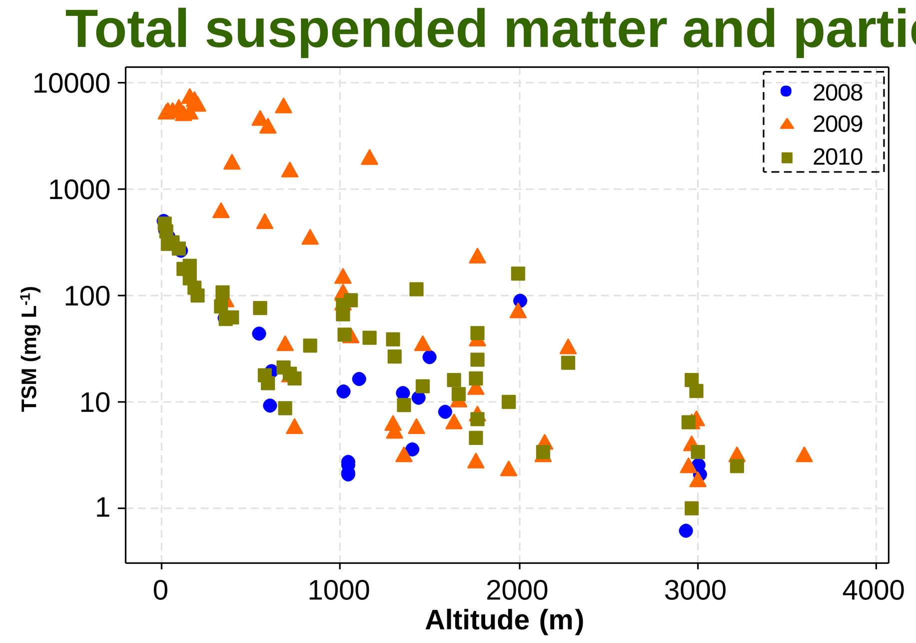

Figure 2: Altitudinal profile of TSM

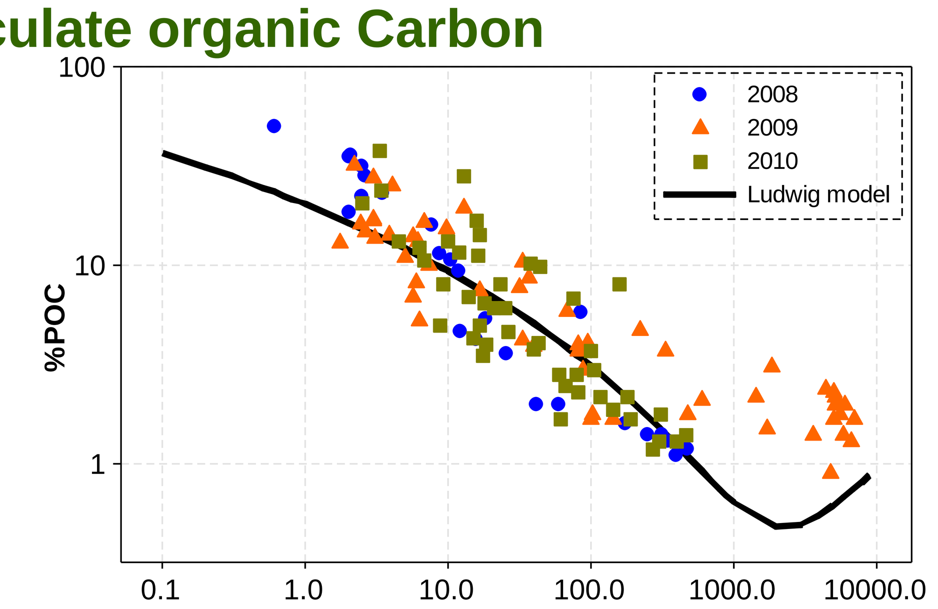

Figure 3: Comparison of % POC and TSM along Tana River Basin and Ludwig et al., 1996 Model

- A consistent downstream increase in TSM was observed during all three sampling campaigns.
- TSM values were similar for the dry-season and end-of-wet-season datasets (p>0.05), but significantly higher during the wet-season campaign.
- The POC concentrations shows similar trends as those in TSM, i.e. a consistent downstream increase during all sampling campaigns (p<0.01).
- TSM & %POC followed the classical inverse relationship for all seasons sampled i.e. dilution of %POC with increase in TSM (p<0.01).

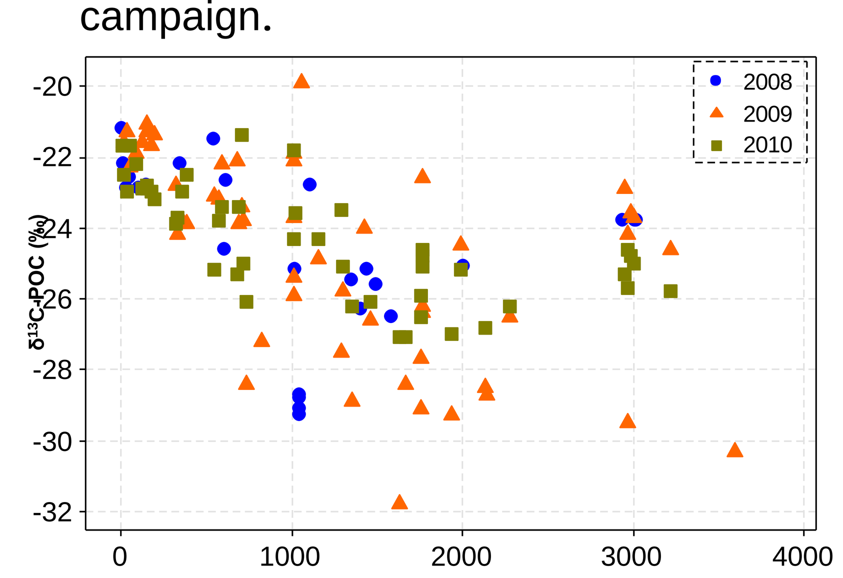

Figure 4: Altitudinal profile of δ^{13}C-POC

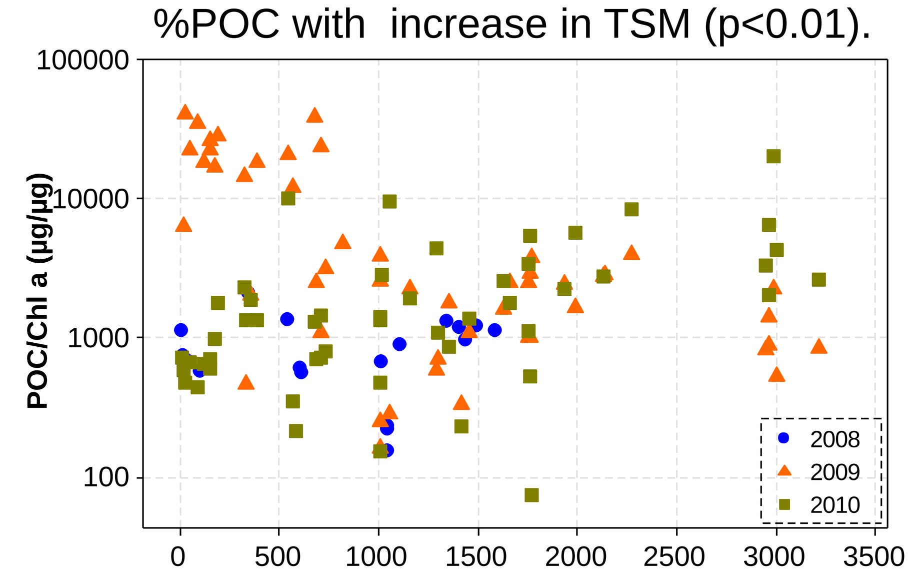

Figure 5: Altitudinal profile of POC/Chl *a* ratios

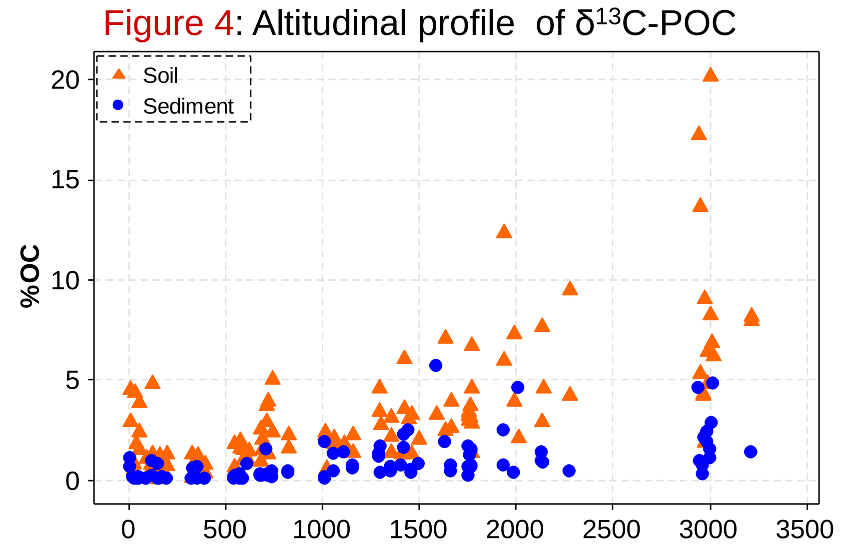

Figure 6: Altitudinal profile of soil and sediment % OC

- The %POC/TSM relationship fits well with empirical Model based on Ludwig et al. (1996) data.
- δ^{13}C-POC increased downstream during all three sampling campaigns (p<0.01), and were predominantly of terrestrial origin as reflected by generally high POC/Chl a ratios. This trend thus reflects an increasing contribution of C4-derived carbon downstream. However, different seasons were not significantly different (p>0.05).
- Soil and sediment %OC decreased consistently downstream (p<0.01) due to minimal organic matter decomposition in high altitude for soil. Sediment had less %OC compared to soil due to large particle size.

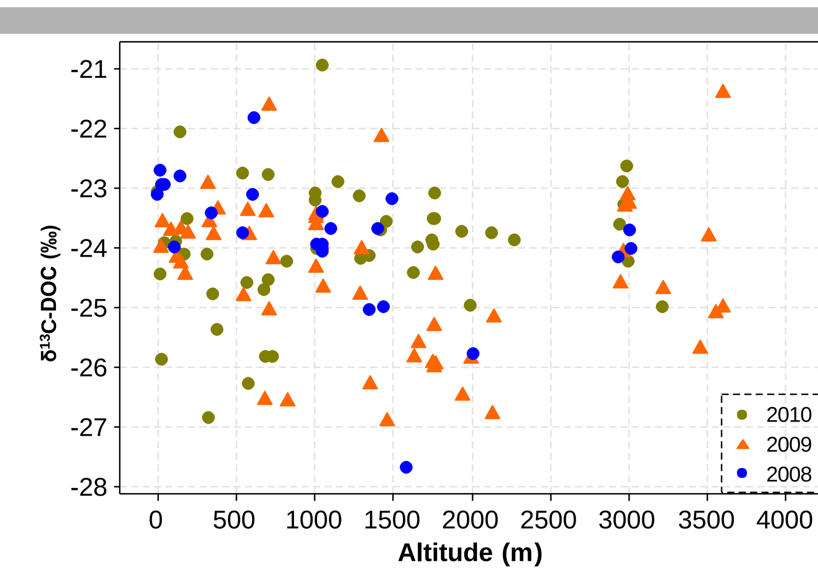

Figure 7: Altitudinal profile of δ^{13}C-DOC

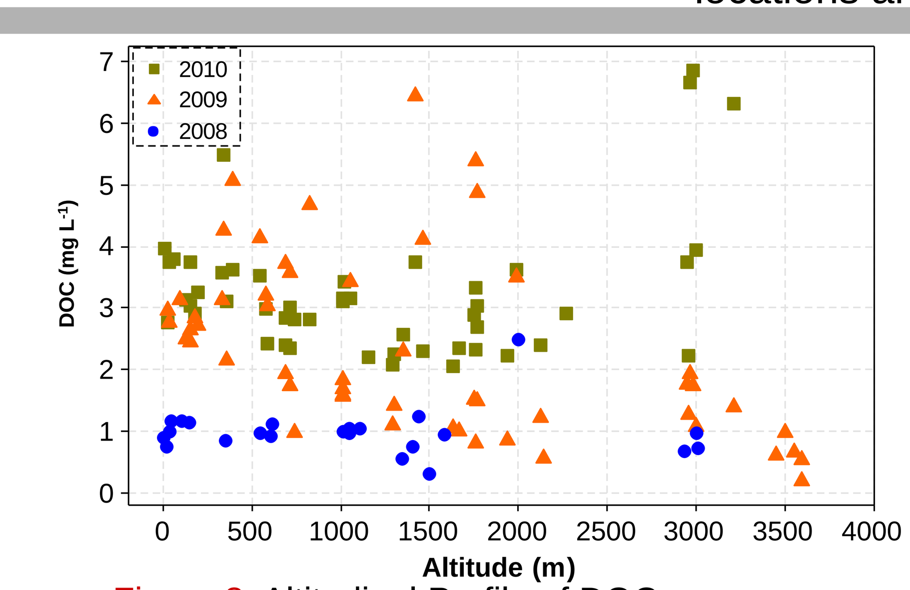

Figure 8: Altitudinal Profile of DOC

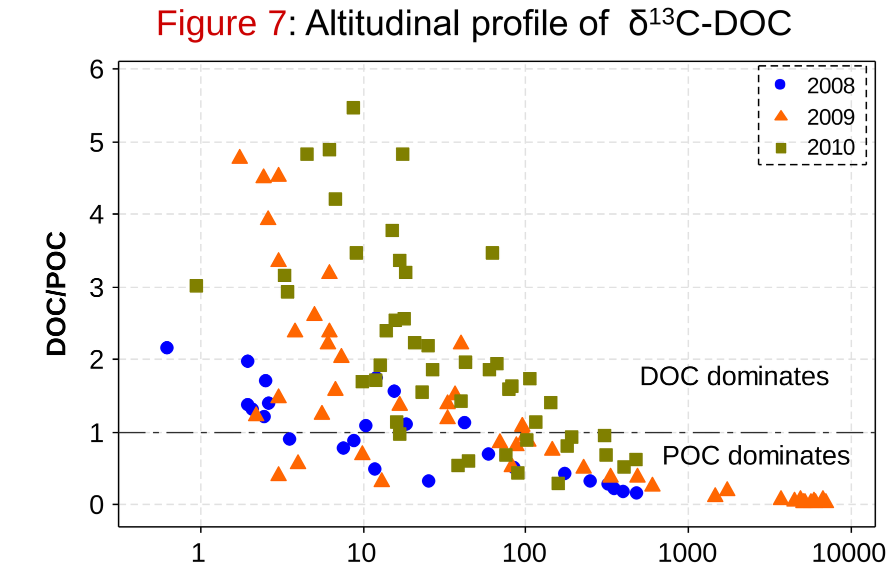

Figure 9: Relation between DOC:POC ratios & TSM.

- DOC concentration was higher in wet-season due to flushing effect of organic. matter
- The range of δ^{13}C-DOC values (-27.7 to -20.9‰) suggests the source of DOC is predominantly of C3 origin and minimal or no in-stream autochthonous production .
- The DOC:POC ratios show a significant inverse relationship with TSM typical of an erosive riverine system.

Seasonal variation in organic composition

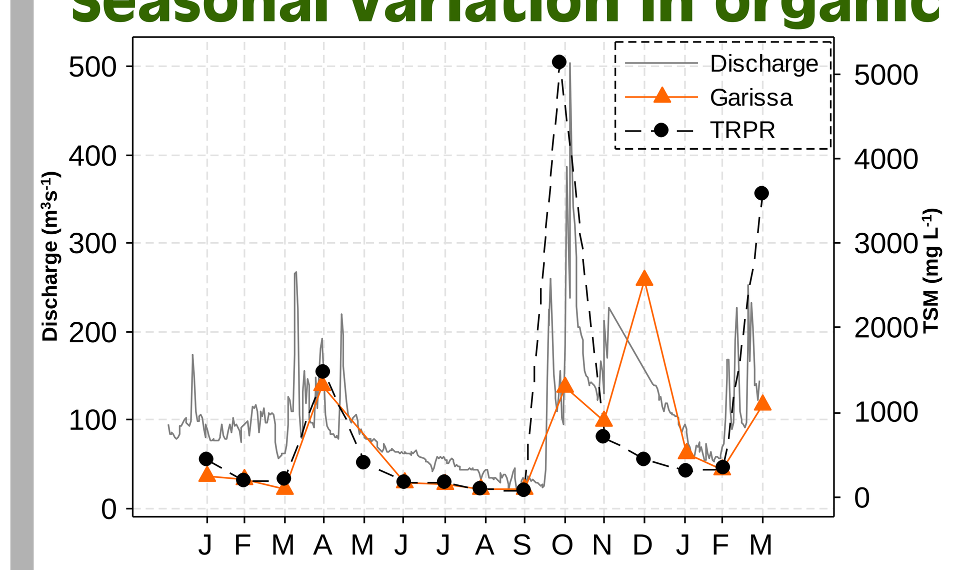

Figure 10: Discharge Superimposed with TSM

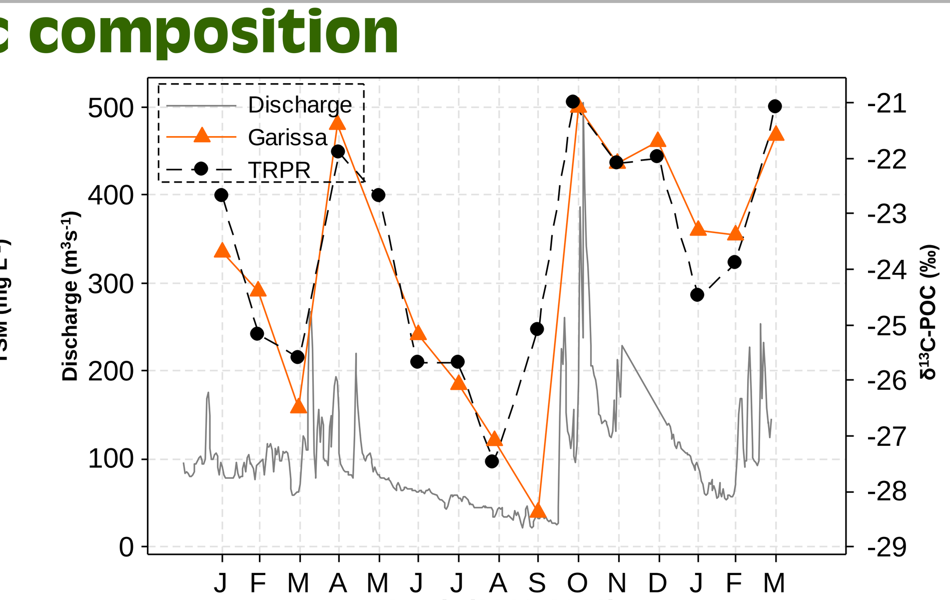

Figure 11: Discharge Superimposed with δ^{13}C-POC

- As expected, TSM and POC were highly episodic and highest in periods with high discharge
- Both TSM and POC maxima preceded peak discharge, particularly at TRPR station as observed previously by Kitheka et al. (2005). This suggests release of relatively mobile sediments during initial peak discharge.
- Seasonal patterns in δ^{13}C-POC signatures at both stations coincided closely, with δ^{13}C increasing markedly during periods of high discharge (-23 to -21 ‰), and decreasing towards predominantly C3 signatures toward the end of dry periods. This suggests that high sediment mobilization during rains occurs mostly in areas with significant grassland cover (C4).

Conclusions

- δ^{13}C constrained from organic matter show C3 derived organic matter dominate the riverine DOC and POC pools.
- High POC:Chl *a* ratios suggest negligible contribution from in-stream phytoplankton production.
- TSM and POC delivery is episodic during peak discharge, and mostly mobilized at intermediate altitudes
- In the lower section of the Tana River, POC mainly originates from areas with a significant contribution by C4 plant species during high discharge, while during low discharge POC is predominantly derived from C3 plant species.

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