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On the early processing of terrestrial organic matter released to (sub-)Arctic coastal waters as deduced from biomarkers, isotopes and a simple model

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The surface layer of the vast sub-Arctic and Arctic tundra and taiga holds over a third of the global soil carbon and this area is now experiencing among the largest climate warming of anywhere on Earth. Yet, there is a shortage of investigations of the biogeochemical fate of coastally exported terrestrial organic matter (terrOM) from these systems, in part due to the inaccessibility of the large Eurasian-Arctic shelves. This paper seeks to synthesize initial findings from a large-scale survey of single surface sediments outside the five Great Russian Arctic Rivers (GRARs; Ob,Yenisey, Lena, Kolyma and Indigirka) and from detailed process-studies of a water column and surface sediment transect off pristine sub-Arctic Kalix River, one of the largest unregulated rivers in Europe draining into the northernmost Baltic Sea.

There is at present a discrepancy in the literature of how the early (water column) fate of terrestrial organic matter is believed to occur between the northern Baltic Sea and the Eurasian Arctic shelf seas. For the Baltic, one suggests substantial DOC degradation but no consideration of POC degradation. For the Arctic, terrestrial DOC is believed to be conservatively mixed while POC is assumed to follow a generic "global" average degradation.

Our studies to date show that terrOM entering sub-Arctic Baltic and Eurasian-Arctic seas follows continent-scale trends in molecular and isotopic composition. Sphagnum is a key contributor to the pre-aged (1000s of 14C years) terrOM in these coastal waters with greatest Sphagnum contribution but youngest terrOM toward the west. The Kalix-Baltic transect revealed rapid degradation of acyl lipids along the 80 km distance from river mouth to the open bay. For instance, the ratio of HMW n-alkanoic acids to HMW n-alkanes in surface water suspended particles dropped from 2.7 to 1.2. There was also rapid degradation during settling and in the surface sediment as the same ratio in sediments dropped between the estuary - open bay from 1.5 to 0.2.

A simple box model was parameterized with measurements of advective river input, settling fluxes and advective export and solved for degradation. The model was run for both individual biomarkers, bulk POC and bulk DOC. Rapid terrPOC degradation was constrained (65% during 5-day box transit). This translated into a degradation rate for terrPOC that is nearly 20 times more rapid as for terrDOC, which makes both pools roughly equally important for the total terrOM degradation. Similar trends for POC-biomarkers and degradation indexes between the Kalix-Baltic and GRAR systems suggest that the early processing may be similar on the Eurasian Arctic shelf.