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Bacterial production in the water column of small streams highly depends on terrestrial dissolved organic carbon

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In the recent years it has become clear that the largest part of the terrestrial dissolved organic carbon (DOC) pool is removed on the way from the land to the ocean. Yet it is still unclear, where in the freshwater systems terrestrial DOC is actually taken up, and for streams DOC uptake was assumed to happen mostly at the stream bottom (benthic zone). However, a recent monitoring study implies that water column but not benthic bacteria are strongly affected by the amount and composition of DOM entering streams from the terrestrial zone.

We conducted an experiment to compare the reaction of the bacterial production and heterotrophic uptake in the water column and the benthic zone to a standardized source of terrestrial DOC (leaf leachate from Beech litter). In detail, we sampled gravel and water from eight streams with a gradient in stream size and land use. For each stream four different treatments were incubated at 16°C for three days and each stream: filtered stream water with gravel stones (representing benthic zone bacteria) or unfiltered stream water (representing water column bacteria), both either with (n = 5) or, without (n = 3) leaf leachate. We found that the bacterial uptake of leaf litter DOC was higher for the benthic zone likely due to the higher bacterial production compared to the water column. In contrast, the bacterial production per amount of leaf leachate DOC taken up was significantly higher for the bacteria in the water column than for those in the benthic zone. This clearly indicates a higher growth efficiency with the leaf leachate DOC for the bacteria in the water column than in the benthic zone. We found a high variability for the growth efficiency in the water column, which was best explained by a negative correlation of the DOC demand with stream width (R^2 = 0.86, linear correlation of log-transformed data). This was not the case for the benthic zone bacteria (R^2 = 0.02). This implies that water column bacteria in very small streams are more dependent on terrestrial DOC sources for their growth than those in larger streams.

Based on this experiment and literature data we hypothesize that: I) The response of the bacterial production to terrestrial DOC in the water column is stronger than for the benthic zone and is decreasing with increasing stream size, likely due to the increase of autochthonous DOC production within the stream. II) Independent of stream size there is only a small reaction to terrestrial DOC for the bacterial production in the benthic zone, either due to internal DOC production or a stronger dependency on particulate organic carbon. We propose that this terrestrial DOC dependency concept is generally applicable, however, its potential underlying mechanisms and concept predictions need to be tested further for other stream and river ecosystems.