Mapping sediment carbon in a large tropical reservoir: burial of terrestrial and aquatic organic carbon, and occurrence of potential methane ebullition hot spots

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Reservoirs efficiently trap the riverine sediment flux, and therefore rapidly accumulate sediment. Since the sediments contain organic carbon (OC), reservoirs globally store significant amounts of OC in their sediments. The source of the OC buried in reservoir sediments is currently not well-known, but has important implications for the accounting of reservoir C burial as a new anthropogenic C sink. On the other hand, sediment OC can be degraded to the greenhouse gas methane (CH4) in anoxic sediment layers, and at high sediment accumulation rates, CH4 reaches oversaturation and forms gas bubbles which efficiently transport CH4 to the atmosphere. Accordingly, CH4 ebullition (bubble emission) is the main pathway of the globally significant CH4 emission by reservoirs. Both sediment OC accumulation and CH4 production is spatially extremely heterogeneous in reservoirs, and we currently lack understanding of the drivers of this spatial variability. We therefore mapped the spatial variability of sediment OC accumulation and of gas bubble-rich, CH4-oversaturated sediments in a large (1300 km2) tropical reservoir in Brazil, using both seismic sub-bottom profiling and sediment coring. In addition, we performed analyses of the sediment stable isotopic signature (13C and 15N) and lipid biomarkers (alkanes, alkanols, and acids) in order to discern the origin of the buried OC. We found that the OC accumulation rate was strongly dependent on the sedimentation rate, which in turn varied with water depth, bottom slope and proximity to river inflows. The spatially-resolved mean OC burial rate was 44 g C m-2 yr-1, twice as high as the global average for natural lakes, but lower than the global average for reservoirs. Gas bubble-containing sediment was detected in 30% of the sub-bottom survey length and occurred along the whole reservoir, but was most abundant in areas of high primary productivity, high sediment accumulation rate, and < 25 m water column depth. Evidence from stable isotopes and lipid biomarkers indicates that a significant share of the OC accumulating in the reservoir sediment is of aquatic origin, and therefore is accountable as a new C sink that results from reservoir construction. These results indicate that the spatial variability of both the burial of OC from terrestrial and aquatic origin, and of gas bubble-rich sediments prone for CH4 ebullition can be understood from the reservoir characteristics.

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