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Editorial: Riverine Biogeochemistry Under Increasing Damming: Processes and Impacts

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Editorial on the Research Topic

Riverine Biogeochemistry Under Increasing Damming: Processes and Impacts

Rivers around the world are increasingly impounded by dams to secure water supplies to local communities, irrigated agriculture and industries, and to provide public services including hydropower production, flood control, inland navigation and recreation (Zarfl et al., 2015). Dammed reservoirs supply around 30%–40% of the world's irrigation water (Yoshikawa et al., 2014) and 16% of the world's electricity (REN21, 2016). It is estimated that more than 6,700 dams with backwater surface areas larger than 0.01 km^2 have been constructed on the world's rivers and the total number of all dams exceeds 16 million, with a total water storage volume of 8,069 km^3 (Lehner et al., 2011; Messager et al., 2016). As a consequence, only 37% of the world's large rivers longer than 1,000 km remain free flowing (Grill et al., 2019).

River damming redistributes seasonal and annual water flows, and causes major changes to the ecology and biogeochemistry of rivers and downstream ecosystems (Poff et al., 2007). Most importantly, reservoirs substantially extend water residence time, causing enhanced instream metabolism, nutrient retention and greenhouse gas emissions from reservoirs and downstream rivers (Chen et al., 2020; Maavara et al., 2020). These processes substantially change the role of river systems as "reactors," yet these effects are not well understood due to their large spatial and seasonal variability within both natural rivers and reservoirs. To quantity and manage perturbations by river impoundments necessitates improved mechanistic understanding of the causes, strength, and duration of reservoir-specific processes. Considering large seasonal variability in both natural and managed reservoirs, year-round field or modeling studies are particularly important.

The aim of this research topic is to gather studies that extend our understandings of how reservoirs perturb the hydrology, biogeochemistry and ecology of rivers through novel field and/or theoretical investigations on relevant mechanisms and processes. The research topic includes five primary research articles that cover three different topics: greenhouse gas emissions from reservoirs (Sawakuchi et al.; Wu et al.; Yan et al.), the impact of dam operation on riparian vegetation (Swanson and Bohlman), and the modeling of dissolved gas saturation during spillway water releases from high dams (Peng et al.). Investigated regions included subtropical reservoirs in southwest China (Peng et al.; Wu et al.), tropical lowland reservoirs in Amazonia (Sawakuchi et al.; Swanson and Bohlman) and a global scale study (Yan et al.). These studies provide new perspectives that enhance the scientific community's understanding of dam related riverine perturbations in different geographic contexts.

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Sawakuchi et al. examined CH_4 dynamics in the main channel and downstream of the Santo Antônio hydroelectric reservoir, a large run-of-river reservoir in tropical Amazonia. Their results suggest substantial CH_4 production in the reservoir's littoral sediment, but simultaneous high CH_4 oxidation in the main channel which kept the concentration and fluxes of CH_4 low. It was suggested that, in comparison to impoundment reservoirs, the run-of-river design of the reservoir was able to maintain high mixing and oxygenation in the reservoir's water column with the potential to mitigate CH_4 emissions.

Wu et al. investigated the spatial and seasonal dynamics of N_2O emission from cascade reservoirs on the Wubu River in southwest China. In contrast to effective oxidation of CH_4 in the tropical run-of-river reservoir (Sawakuchi et al.), their results suggest higher N_2O concentration and emission rates in the reservoirs and released waters than in upstream river sections, making the cascade reservoirs hotspots for N_2O emission. They concluded that long water residence times, high nutrient loads and high biological activities could enhance nitrogen release, transformation and N_2O emission from cascade reservoirs.

Yan et al. investigated the spatial and temporal variations of greenhouse gas (CO_2, CH_4 and N_2O) concentrations and emission rates in global reservoirs based on a compiled dataset. They estimated that global reservoirs emitted annually 12.9 Tg CH_4-C, 50.8 Tg CO_2-C, and 0.04 Tg N_2O-N to the atmosphere. Importantly, the highest increase rate in reservoir greenhouse gas emissions occurred during the 1950s–1980s, corresponding a surge in reservoir construction in North America and Western Europe.

Swanson and Bohlman evaluated the impact of large reservoir construction on riparian vegetation changes in the Tocantins River of Amazonia. Their findings support the idea that reservoir filling threatens the integrity of ecosystem services provided by riparian vegetation *via* creating new riparian zones surrounding the reservoirs and causing deforestation downstream of dams. They concluded that the disturbances to native riparian vegetations may take decades or longer to recover.

Finally, Peng et al. developed a water renewal model which incorporates water residence time to predict total gas supersaturation during water release over the spillways of high dams. The results show that the model performed better than classical empirical models and mechanical models and was able to aid in mitigating the ecological risk of supersaturated gases generated during dam operation.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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