Greenhouse gas dynamics in an anthropogenically modified tropical river continuum

Siddhartha Sarkar1,2, Ajayeta Rathi1,2, and Sanjeev Kumar1

1Geosciences Division, Physical Research Laboratory, Ahmedabad, India (siddhartha@prl.res.in, ajayeta@prl.res.in, sanjeev@prl.res.in)
2Indian Institute of Technology Gandhinagar, India (siddhartha.sarkar@iitgn.ac.in, ajayeta_r@iitgn.ac.in)

Recent decades have witnessed large scale modifications in the natural flow regime of river systems. What follows are shifts in various instream processes that ultimately govern the air-water fluxes of major greenhouse gases (GHGs) like CH\(_4\), CO\(_2\), and N\(_2\)O. However, due to paucity of data, the process dynamics and controls on fluxes of GHGs in tropical rivers are understudied, contributing to uncertainty in their global budget. In this study, an attempt was made to estimate the fluxes of GHGs and thereby decipher the controls on evasive processes in an anthropogenically affected Sabarmati River (catchment ~ 27,674 km\(^2\) and channel length ~371 km) located in semi-arid western India. After originating from a relatively pristine region, Sabarmati passes through a major twin city (Ahmedabad-Gandhinagar), where construction of a riverfront resulted in increased residence time of water within the city limits.

To compare and understand changes in in-stream biogeochemical processes as a result of human interventions, sampling was carried out at 50 sites along the Sabarmati river continuum and a parallel running, but not so anthropogenically modified, Mahi River along with their tributaries. Results indicated relatively lower fluxes of GHGs in pristine upstream of Sabarmati and Mahi River continuum with CH\(_4\), CO\(_2\) and N\(_2\)O fluxes at 0.99 ± 0.35 mg C m\(^{-2}\) d\(^{-1}\), 4250.99 ± 477.74 mg C m\(^{-2}\) d\(^{-1}\) and 0.055 ± 0.026 mg N m\(^{-2}\) d\(^{-1}\) respectively. The effect of higher residence time of water could be seen in the riverfront with increased CH\(_4\) and N\(_2\)O fluxes at 3.27 ± 1.02 mg C m\(^{-2}\) d\(^{-1}\) and 0.129 ± 0.024 mg N m\(^{-2}\) d\(^{-1}\), respectively. However, the CO\(_2\) flux did not show much increase. The fluxes increased significantly post city limits until its mouth in the Arabian Sea with extremely large flux for methane (CH\(_4\): 102.84 ± 41.32 mg C m\(^{-2}\) d\(^{-1}\), CO\(_2\): 9563.58 ± 1252.43 mg C m\(^{-2}\) d\(^{-1}\), and N\(_2\)O: 0.16 ± 0.11 mg N m\(^{-2}\) d\(^{-1}\), respectively). Overall, it appeared that even within the anthropogenically stressed river, the nature of flow regime, exerts significant control on cycling of elements leading to differential fluxes. Also, the level of coupling between nitrogen and carbon appeared to change within the course of the river.