CH$_4$ and CO$_2$ emissions and carbon imbalance in a 10-years old tropical reservoir (Petit-Saut, French Guiana)

ABRIL G. $^1$, F. GUERIN $^{1,3}$, S. RICHARD. $^2$, R. DELMAS $^3$

$^1$ EPOC, UMR CNRS 5805, Université Bordeaux I, Talence, France.
$^2$ Laboratoire Environnement, Hydreco, Kourou, France
$^3$ Laboratoire d’Aérologie, UMR CNRS 5560, OMP, Toulouse France

In recent years, there has been an increasing concern on greenhouse gas emissions from artificial reservoirs, particularly in the tropics where the flooding of large amounts of primary forest together with high temperatures lead to high methane emissions. In this study, the emissions of carbon dioxide (CO$_2$) and methane (CH$_4$) from the Petit Saut hydroelectric reservoir (Sinnamary River, French Guiana) to the atmosphere were quantified for 10 years since impounding in 1994. Diffusive emissions from the reservoir surface were computed from direct flux measurements in 1994, 1995 and 2003 and from surface concentrations monitoring. Bubbling emissions, which occur only at water depths lower than 10 m, were interpolated from funnels measurements in 1994, 1997 and 2003. Degassing at the aerating weir downstream the turbines was calculated from the difference in gas concentrations upstream and downstream the dam and the turbined discharge. Diffusive emissions from the Sinnamary tidal river and estuary were quantified from direct measurements in 2003. Total carbon emissions were 0.33±0.01 MtC.y$^{-1}$ (CO$_2$: 0.26±0.02; CH$_4$: 0.07±0.01) the first 3 years after impounding (1994-1996) and then decreased to 0.12±0.01 MtC.y$^{-1}$ (CO$_2$: 0.10±0.01; CH$_4$: 0.016±0.006) since the year 2000. On average over the 10 years, 67% of the CO$_2$ emissions occurred by diffusion from the reservoir surface, 25% from the estuary, 8% by degassing at the weir and a negligible fraction by bubbling. CH$_4$ diffusion and bubbling from the reservoir surface were predominant (respectively 40 and 44%) only the first year after impounding. Since 1995, degassing downstream the turbines has become the predominant pathway for CH$_4$ emissions, reaching 60-70% of the total CH$_4$ flux. A carbon budget of the whole system for the year 2003 that considers riverine inputs and outputs and gaseous emissions reveals that the carbon pool flooded initially is the predominant contributor to the gaseous emissions. In 10 years, about 20% of the 10MtC flooded was lost to the atmosphere. The carbon lost showed a decreasing trend with time typical for a decomposition kinetics of organic matter. A simple model with three fractions of organic matter (one rapidly decomposing, one slowly decomposing, one refractory) fitted well to the data. Our results confirm the significance of greenhouse gas emissions from tropical reservoir but stress the importance of (1) considering all the gas pathways upstream and downstream the dams; (2) taking into account the reservoir age when upscaling emissions rates at the global scale.