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GHG budget in a young subtropical hydroelectric reservoir: Nam Theun 2 case study

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Dynamics of major greenhouse gases (CO_2, CH_4 and N_2O) has been studied in a new subtropical hydroelectric reservoir (impounded in 2009), Nam Theun 2 (NT2), in Lao PDR, Asia. The main pathways of emission were quantified, i.e., ebullition (bubbling), surface diffusion, downstream emissions (diffusion and degassing) and emissions from the drawdown area (up to 370 km^2 for a 450km^2 in the case of NT2). All presented results are coming from five field campaigns conducted from May 2009 to June 2011, and a monthly monitoring on 35 stations. Additional laboratory work in controlled conditions helped to assess production rates of CH_4, CO_2 and N_2O, and aerobic CH_4 oxidation rates.

The ebullition of CH_4 is in the same order as from other tropical reservoirs, varying with depth and atmospheric pressure. Measured diffusive fluxes of CH_4 and CO_2 cover the whole range of reported fluxes for other tropical reservoirs, depending on the season. Diffusive fluxes of N_2O, and CH_4 downstream (degassing and diffusion) emissions are in the lower range as reported before for tropical reservoirs. On the opposite, the drawdown area would represent a significant contribution to N_2O emission.

Our results for the year 2010 show that diffusive emission from the reservoir surface is the main contributor (46%) to total GHG emissions from the NT2 reservoir. With 25% and 19% of total GHG emissions, bubbling and drawdown area emissions also contributed significantly respectively. Downstream emissions from NT2 reservoir contributed around 10% of total GHG emissions, a percentage lower than reported for other reservoirs. With 963 Gg CO_2eq yr^{-1} and 986 Gg CO_2eq yr^{-1}respectively, CH_4 and CO_2 have almost the same contributions (48 and 49%) of the total GHG budget, N_2O accounting for less than 3% with 64 Gg CO_2eq yr^{-1}. With a total emissions from NT2 reservoir of 2013 Gg CO_2eq yr^{-1}, gross NT2 emission are about an order of magnitude higher than pre-impoundment emissions (276 Gg CO_2eq yr^{-1}). Net emission, that is the difference between post and pre-impoundement emissions (determined in 2008), which is the actual anthropogenic disturbance related to the reservoir creation is equal to 1737 Gg CO_2eq yr^{-1}. From the annual power generation of NT2 (about 6 TWh), this leads to an GHG emission factor of 0.33 Mg of CO_2eq MWh^{-1}, to be compared to a typical thermal power plant emission factor of 0.85 Mg of CO_2eq MWh^{-1}. This 2010 emission factor corresponds to the first year after impoundment for NT2, and as such, can be considered as the maximum value that will be reached for this reservoir.

Keywords: Aquatic ecosystem, carbon cycling in hydroelectric reservoir, GHG production, aerobic methane oxidation, GHG emission pathways, GHG budget, subtropical reservoir.