

Gas Transfer Velocities in a Tropical Reservoir and its River Downstream: Wind Speed and Rainfall Effect.

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We have measured simultaneously the methane (CH₄) and carbon dioxide (CO₂) surface concentrations and fluxes in the Petit-Saut reservoir (French Guiana) and its tidal river (Sinnamary River) downstream the dam, during two field experiments in wet (May 2003) and dry season (December 2003). Gas fluxes were measured with floating chambers (FC) on the artificial lake and on the river, and with the eddy covariance (EC) technique for CO₂ during a 24h experiment on the lake. For each chamber measurement, wind speed was measured at 1m above the water surface and recalculated at 10 m using the formulation proposed by Amorocho et DeVrie (1980). During the 24h EC experiment the wind speed at 10m (U₁₀) and the rainfall rates were recorded by a meteorological station. For each flux measurement the gas transfer velocity normalized for a Schmidt Number of 600 was computed.

On the lake and excluding all rainy events, we obtained cubic relationships between k₆₀₀ and U₁₀ for both gases (k₆₀₀ (CH₄) = 2.02 + 0.03U₁₀³ n= 38, FC fluxes and k₆₀₀ (CO₂) = 2.81 + 0.036U₁₀^{2.8} n= 127, FC and EC fluxes). The comparison of individual FC and EC k₆₀₀ for CO₂ showed some discrepancies due to differences in measurements durations (FC: 5-10 min versus EC: 30 min) which resulted in different average wind speeds (FC: 0.18 to 7.8 m.s⁻¹; EC: 0.18 to 3.87 m.s⁻¹). Nevertheless, when comparing FC and EC K₆₀₀ for a given wind speed, both methods gave similar results. At low wind speed (U₁₀ ≤ 3 m.s⁻¹), k₆₀₀ (CO₂) was significantly higher than k₆₀₀ (CH₄) suggesting the occurrence of chemical and/or biological enhancement of the CO₂ flux in these acid waters (pH=6) with low buffering capacity (Alkalinity 0.1meq.kg⁻¹). k₆₀₀ was also positively related to rainfall rates reaching 29 cm.h⁻¹ for a rainfall rate of 42 mm.h⁻¹. Using a tropical raindrop size distribution, we obtained a linear relationship between the residual k₆₀₀ and the kinetic energy flux consistent with the formulation of Ho et al. (1997). Concerning the wind effect alone, when comparing our results with literature data [Cole and Caraco, 1998 and references therein; Frost and Upstill-Goddard, 2002; Crucius and Wanninkhof, 2003], no evident statistical differences appear from one lake to another.

In the tidal river downstream the dam, we obtained a linear relationship between k₆₀₀ and U₁₀ (k₆₀₀ = 4.24U₁₀ + 5.46) with no significant difference for the two gases and with higher k₆₀₀ than in the lake due to the turbulence induced by water currents. The slope of this linear relationship fitted well to the formulation as a function of surface area (on a log-log scale) proposed by Borges et al. 2004. This confirms that, in rivers and estuaries, the formulation of k₆₀₀ is site specific, the intercept being related to water current and depth and the slope to fetch limitation (surface area).

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