12 Long Term Greenhouse Gas Emissions from the Hydroelectric Reservoir of Petit Saut (French Guiana) and Potential Impacts

Robert Delmas, Sandrine Richard, Frédéric Guérin, Gwénaël Abril, Corinne Galy-Lacaux, Claire Delon and Alain Grégoire

Abstract

This paper summarizes, in a first part, results of greenhouse gas emissions from the hydroelectric reservoir of Petit Saut in French Guiana obtained during the three first years after impoundment (1994-1997). Results from three years of measurements have been extrapolated to estimate trends in methane emissions and the carbon budget of the reservoir over a 20-year period. Extrapolations were made using the global warming potential concept to calculate cumulative greenhouse gas emissions at a 100-year time horizon and to compare these emissions to potential emissions from thermal alternatives. In a second part, we analyze new data from long term continuous observations (1994-2003) of methane concentrations in the reservoir and flux data obtained during a recent campaign in May 2003. These data confirm predicted trends and show some suitable adjustments. They constitute a unique data base which is used for the development of a model to simulate both water quality and greenhouse gas emissions from tropical artificial reservoirs.

12.1 Introduction

Over the two last decades increasing concentrations of greenhouse gases (GHG) in the atmosphere contributing to an enhanced greenhouse effect have become a major environmental issue. The main contributor to this effect is, by far, fossil fuel combustion. Until recently, it was believed that
hydroelectric energy was a clean energy source compared to thermal energy production, with almost no impact on the greenhouse effect. The creation of artificial lakes modifies biosphere-atmosphere exchanges on a local scale. Carbon dioxide and methane are mostly produced from organic matter decomposition under anaerobic conditions, generating a source of greenhouse gases. From theoretical considerations Gagnon and Chamberland (1993), Svensson and Ericson (1993), and Rosa and Shaefter (1994) suggested that artificial reservoirs could constitute an anthropogenic source of greenhouse gases. This was confirmed by the first flux measurements on boreal reservoirs (Kelly et al. 1994; Duchemin et al. 1995). More recently, Fearnside (1995) calculated that some tropical reservoirs may emit more greenhouse gases than thermal power plants of equivalent power output. Field measurements conducted on Petit Saut reservoir in French Guiana, since reservoir impoundment in 1994, confirmed that tropical reservoirs can be quite a significant source of both carbon dioxide (CO₂) and methane (CH₄) (Galy-Lacaux et al. 1997). Results presented in this last paper also highlighted the influence of methane produced within the reservoir on water quality showing that methane oxidation could be responsible for high oxygen depletion in the whole hydro system, including both the reservoir and the river downstream of the dam. A recent global scale assessment of GHG emissions from reservoirs (Saint-Louis et al. 2000), suggests that artificial reservoirs, whose total area is of the order of 1500000 km², could be a major anthropogenic source of methane representing 64 MT·y⁻¹, 90% of emissions occurring from tropical latitudes. It is now recognized that artificial reservoirs are a GHG source, however, such global estimates are highly speculative since they rely on a very limited number of data sets. More work is clearly needed in order to better define the order of magnitude of this source and to compare it with emissions from other land surfaces, both natural (wetlands) and anthropogenic (rice paddy fields).

In this paper we first review results from the literature dealing with emission trends over 20 years from the Petit Saut reservoir (Galy-Lacaux et al. 1999). We then on a calculate, on a 100-year time scale, the net GHG emissions from this reservoir and compare the results with GHG emissions from thermal alternatives (Delmas et al. 2001). These results allow some preliminary conclusions to be drawn about hydroelectric energy and greenhouse gas emissions. The regular measurements of chemical parameters of the reservoir water column between 1997 and 2002 allow for the evaluation of the accuracy of the comparison between hydroelectric and thermal energy production. A new program was launched at the beginning of 2003 in order to reduce uncertainties pertaining to this question. This program includes new observations and modeling of which the first recent results are presented in the last section of this chapter.