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Subtropical freshwater storages: a major source of nitrous oxide and methane?

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Studies of greenhouse gas cycling in subtropical water bodies, particularly in the Southern Hemisphere, are very limited. This represents an important gap in our understanding of global emissions as the higher temperatures experienced in the subtropics will likely accelerate greenhouse gas production and consumption. Critical to understanding the net impact of these accelerated rates are detailed studies of representative systems within this region. In this paper we present a model artificial freshwater storage: Gold Creek Dam in South East Queensland, Australia.

Freshwater storages are commonplace for drinking water and irrigation purposes in Australia as unpredictable rainfall patterns make river and ground water sources unreliable. Over 85 % of Australian rivers are modified with weirs and dams providing permanent inundation of previously terrestrial environments. The higher temperatures experienced at these latitudes drive thermal stratification of these systems as well as rapidly deoxygenate bottom waters. High organic matter availability in the sediment zone as well as the anoxic overlying water provide ideal conditions for reduced products (including methane and ammonia) from microbial processing to be formed and diffuse into bottom waters. A mid-water metalimnion is generally associated with large gradients in dissolved oxygen availability and reduced metabolites undergo oxidation prior to their emission from water surface. An intensive field study was undertaken to improve understanding of production and transformation rates of methane and nitrous oxide from the sediments, through the water column and to the atmosphere. Sediment nutrient (ammonia, nitrite/nitrate and filterable reactive phosphorus) and greenhouse gas (methane and nitrous oxide) porewater samples were collected at selected sites. To determine the magnitude of the benthic sediment contribution of methane and nitrous oxide to the water column sediment incubations were conducted in the laboratory. To determine the likely atmospheric flux from this water body surface floating chambers were used to collect gas. Results showed maximum methane concentrations in the sediment porewaters and deeper water column, both anoxic environments. However, nitrous oxide had highest concentrations at the oxycline zone of the water column. Sediment incubations showed clear methane efflux demonstrating the sediments to be a consistent source of methane. Sediments were either a source or sink of nitrous oxide depending on overlying dissolved oxygen concentration. Floating chamber incubations clearly demonstrated Gold Creek Dam was a source of both methane and nitrous oxide with methane an order of magnitude higher expressed as CO_2 equivalents. Diffusive atmospheric fluxes of methane ranged from 20 to 450 mg m-2 d-1 and were comparable to tropical reservoirs rather than temperate reservoirs (LOUIS et al., 2000).

Results are likely to be globally relevant as an increasing number of large dams are being constructed to meet growing water demand and under a warming climate process occurring in subtropical systems can give insights into future changes likely to occur in temperate systems.