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The effect of water oxygen content on the production of greenhouse gases from shallow pond sediments

Adam Freer (1), John Quinton (1), Ben Surridge (1), and Niall McNamara (2)

(1) Lancaster University, Lancaster Environment Centre, Lancaster, United Kingdom (a.freer@lancaster.ac.uk), (2) Centre for Ecology and Hydrology, Lancaster Environment Centre, Lancaster, United Kingdom (nmcn@ceh.ac.uk)

Shallow lakes and ponds, including those commonly found in agricultural landscapes are often only a few metres deep, with surface areas <1ha. Despite this, landscapes may contain a high number of these ponds, amounting to a considerable cumulative surface area. Many of these features, both naturally formed and man-made, receive and trap runoff with high nutrient and sediment loadings. As such, the potential for the production of greenhouse gases (GHGs) through biogeochemical cycling in the pond sediments may be significant. Furthermore, the abundance of available nutrients coupled with the shallow physical characteristics of these systems, mean that short, irregular eutrophic episodes during the summer are common, causing large fluctuations in the oxygen content of the overlying water column. The oxygen content of the water column is often cited as key factor in the production of GHGs in large lake and reservoir systems. Given the limited research focusing on shallow ponds/lakes, and potential for these systems to be important sources of GHGs, the impacts of variable water oxygen content should be investigated.

Here we present the results from a sediment microcosm experiment utilising sediment cores from an agricultural pond system in Cumbria, UK. Intact sediment cores were incubated in the dark at in-situ temperature and continuously fed with filtered pond water for 2 weeks. During this time the oxygen content of the water was manipulated between fully oxygenated and anaerobic. Measurements of GHG release were based on calculated dissolved gas concentrations present in the water columns of these cores. Results indicated that during times of water column anoxia, production of methane and carbon dioxide increased significantly, despite the presence of substantial quantities of nitrate in the water columns. No change in N2O production was detected. These results indicate that while representing a significant cumulative carbon store in agricultural landscapes, shallow pond and lake systems can contribute to emission of GHGs. Furthermore, the physical and ecological characteristics of these systems have the potential to significantly increase the quantity of gas produced. This understanding will be valuable when constraining both freshwater and agricultural GHG budgets.