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Natural pipes are major carbon pathways in peatlands

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Natural pipes are large macropores which have been reported in most types of northern peatlands. This paper reports on a two year monitoring project which has measured the carbon fluxes from peat pipes in a 17.4 ha deep blanket catchment in northern England. Fluxes of dissolved organic carbon (DOC), dissolved CO2 and CH4 and particulate organic carbon (POC) were monitored by routine sampling and during storm events. Dissolved CO2 was monitored using a continuously logging sensor. The sources of water and carbon from pipes under different antecedent conditions were evaluated using hydrochemical and isotopic analysis. 91 pipe outlets were found in the catchment. These outlets were morphologically dynamic responding relatively quickly to changes in flow or extreme events, linked to short-term changes in weather. The cross-sectional area of 77 of the pipe outlets changed during the study; 18 pipe outlets completely infilled, while 4 new ones appeared. All pipes responded very quickly to rainfall and had flashy hydrographs. The pipes contributed an average of 14 % of stream discharge. It is estimated that more than half of the DOC leaving the catchment was produced by the pipes with pipes producing POC volumes which were equivalent to a third of that leaving the catchment in the stream. Most of the POC and DOC was relatively young (last 30 years) but from some pipes the carbon was old (> 600 years). Some pipes clearly tapped into deep carbon sources, although the water chemistry showed that the carbon and water were not derived from groundwater below the peat mass. Mean pipe water concentrations of CO2 ranged from 0.7 to 6.5 mg L-1, with 0.4 to 1.4 μg L-1 for CH4 equivalent to 3 % and 36 % of export at the catchment outlet. However, values were highly variable between pipes with one pipe producing a value of 4052 μg C L-1 for CH4 which is among the highest ever recorded in flowing water from peatlands. Direct degassing of CO2 and CH4 to the atmosphere from pipe outlets was measured. The pipe outlets were clearly hotspots for degassing with estimates of direct emission rates from pipes being 12.9 g CO2-eq m-2 yr-1 for CO2 and 9.7 g CO2-eq m-2 yr-1 for CH4 across the catchment. Connectivity between pipes and the surrounding peat was variable, being greatest when water tables were high and lowest when water tables were deeper when discharge was associated with CO2-enriched sources. The paper will demonstrate the overall importance of pipes to the fluvial and gaseous carbon budget and will outline the implications for future research.