Nitrous Oxide and Methane Production and Emission in Wetlands Receiving Elevated, Agricultural Nitrate Loads

William Crumpton, *Greg Stenback, David Green, and Jonathan Norton*
Iowa State University, Ames, IA, USA

Although wetland restoration is a promising strategy for reducing nonpoint-source nitrogen (N) loads, these systems can be significant sources of nitrous oxide (N_2O) and methane (CH_4). There is some concern that the widespread restoration of wetlands to intercept and reduce nonpoint source N loads could substantially increase emissions of greenhouse gases (GHG), in particular N_2O. Relatively few studies have quantified N_2O and CH_4 emissions from wetlands receiving elevated, nonpoint-source N loads, and those that do are limited to a relatively narrow range of loads. In addition, prior research has not adequately accounted for dissolved N_2O and CH_4 in water entering or leaving wetlands. These transport pathways represent largely unknown, but potentially significant, N_2O fluxes for wetlands receiving elevated N loads, and failure to consider dissolved N_2O or CH_4 in wetland inflows and outflows could result in a misrepresentation of overall wetland contributions to GHG emissions. This could be critical in the case of wetlands intercepting flows from agricultural tile-drainage systems, which can contain high concentrations of N_2O. Over 100 wetlands have been restored through the Iowa Conservation Reserve Enhancement Program with the explicit goal of intercepting and reducing N loads from tile-drained cropland. These wetlands total over 400 ha of pool area and intercept N loads from approximately 50,000 ha of primarily cultivated cropland. We studied subsets of these wetlands to evaluate their effectiveness at reducing agricultural, nonpoint source nitrogen loads, and to assess their effects on GHG emissions. For each wetland, in addition to measuring nitrate and total nitrogen loading and removal, we quantified N_2O and CH_4 production and emission as well as dissolved N_2O and CH_4 delivered with stream inflow and exported with outflow to downstream systems. Nitrogen loads to the wetlands were primarily in the form of nitrate, and all wetlands were effective at reducing both nitrate and total N loads. The wetlands were also highly efficient at denitrifying nitrate to N_2, with fractional yields of N_2O -N averaging less than 0.5% of total nitrate removal. N_2O emission rates were similar to reported rates from cropland, and CH_4 emission rates were similar to reported rates for restored depressional wetlands in Iowa. External loading and downstream export contributed very little to CH_4 fluxes for any of the study wetlands, which were overwhelmingly dominated by CH4 production and emission. In contrast, external loading and downstream export were major components of the N_2O budgets for all of the study wetlands. N_2O loads to the wetlands from inflow streams ranged from 11-61% of the total N_2O inputs, and N_2O export from the wetlands through outflow to streams ranged from 10-58% of the total N_2O outputs. These results underscore the importance of considering inflows and outflows when interpreting N_2O emissions from wetlands, particularly those systems that receive N_2O loads from agricultural drainage water.