Large aquatic N_2O emissions downstream of intensive horticulture following rain events

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Nutrient leaching from agricultural systems is a global threat to coastal waters. However, the indirect aquatic emissions of the potent greenhouse gas nitrous oxide [N_2O], the primary contributor in stratospheric ozone depletion, remains poorly understood. Here, we assess the influence of episodic rain events flushing an agricultural catchment on nutrients, radon (^{222}Rn, a groundwater tracer) and N_2O emissions. We reveal significant nitrate + nitrite [NO_X] loads and N_2O emissions consistent with N leaching and runoff from a heavily fertilised catchment (Hearnes Lake, Australia). NO_X accounted for 78% of total dissolved N [TDN]. NO_X loads in rain were 695-fold greater than the dry period. Groundwater discharge was found to be a minor source of both NO_X and N_2O to the creek. Fertiliser loss from upstream land uses were ~20% of applied fertiliser. Aquatic N_2O values (up to 5655% sat.) and atmospheric emissions (up to 2859 μmol m^2 day^{-1}) were amongst the highest reported from global waterways. CO_2-eq 20 yr potential emissions and N_2O flux calculations show large variations (10 fold and ~800 fold respectively) between dry and rain periods. Observed N_2O emissions and calculated IPCC EF_5 N_2O emissions were 6.27 N_2O-N yr^{-1} and 29.4 kg N_2O-N yr^{-1} respectively. The estimated N_2O emissions ~2 km downstream of farms were 0.79% of DIN loads and 0.004% of estimated applied fertiliser. On 20 and 100 year timescales, observed N_2O emissions represented ~10% of the total CO_2-eq emissions, which is ~60% higher than the IPCC global average. The high temporal variation in our observations indicates the strong influence of episodic rain events and minor influence of groundwater seepage, highlighting the importance of detailed sampling approaches to capture extreme variability.