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Effects of fermentation slurry and erosion on greenhouse gas fluxes in a young moraine landscape of NE Germany

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A large part of the European landscape is used for agricultural production, but few studies have provided comprehensive datasets on greenhouse gas fluxes of agricultural lands, which are required to develop ecosystem and landscape models (Smith et al. 2010). In particular, the impact of energy crops – often associated with the application of fermentation slurry – and of management-induced erosion and deposition processes on ecosystem gas exchange and the carbon budget of arable sites needs to be investigated in the glacially shaped and agriculturally dominated young moraine landscape of north-eastern Germany. In an interdisciplinary approach, the CarboZALF-D project investigates the impact of various factors such as crop, fertiliser, soil type, and erosion on greenhouse gas fluxes and carbon dynamics in a research site located near Prenzlau, Germany. The current study compares the greenhouse gas balance of plots categorized by different fertilisation regimes and erosion-induced soil types. Fertilisation treatments encompassed sites with 100% organic (fermentation slurry), 50% mineral-50% organic, and 100% mineral fertilisation (reference). Erosion-induced soil types included an eroded Luvisol (erosion), a Colluvic Regosol (deposition), and a non-eroded Haplic Luvisol (reference). All sites were planted with corn (*Zea mays* L.).

Starting in spring 2010, greenhouse gas fluxes (three replicates per site) were measured using a non-flow-through non-steady-state chamber system (Livingston and Hutchinson, 1995) with interval (N_2O, CH_4; gas chromatograph) and continuous sampling (CO_2; LI-840, LI-COR Inc.; Drösler 2005). Air and soil temperatures and photosynthetic active radiation (PAR) were recorded simultaneously to each individual flux measurement. Measurements of N_2O and CH_4 were conducted once every 2-3 weeks. CO_2 measurement campaigns were conducted every 3-4 weeks and encompassed repeated measurements of ecosystem respiration (R_{eco}; opaque chamber) and net ecosystem exchange (NEE; transparent chamber). Measured flux rates were linearly interpolated between measurement campaigns (N_2O, CH_4), or modelled based on continuously logged soil temperatures (R_{eco}) or PAR (NEE).

The application of fermentation slurry considerably affected the N_2O efflux. Plots with 100% slurry fertilisation had significantly higher annual cumulative N_2O emissions (6.8 kg N ha^{-1}) than plots with 100% mineral fertilisation (1.4 kg N ha^{-1}), with intermediate values at plots with mixed fertilisation (4.7 kg N ha^{-1}). The CH_4 efflux was near zero (-0.2 to 0.1 kg C ha^{-1}) regardless of fertilisation type. Rates of R_{eco} tended to be higher in sites with 100% organic fertilisation. Erosion also had a significant impact on greenhouse gas fluxes. Cumulative N_2O emissions showed an increasing trend from the eroded Luvisol (0.6 kg N ha^{-1}) to the non-eroded Luvisol (1.4 kg N ha^{-1}) to the Colluvic Regosol (4.9 kg N ha^{-1}). The Colluvic Regosol also featured the highest uptake of CH_4 (-0.9 kg C ha^{-1}). While NEE rates showed little influence of either fertilisation or soil type, R_{eco}tended to be highest on the Colluvic Regosol, with no consistent differences between the eroded and non-eroded Luvisol plots. The high observed spatial and temporal variability is typical of ecosystem gas fluxes. Consequently, long-term studies such as CarboZALF-D are required to accurately assess the carbon dynamics of agricultural landscapes.

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