HOW DOES DRAINAGE IMPACT GREENHOUSE GAS FLUX EMISSIONS FROM GRASSLANDS AND CROPLANDS ON DRAINED NUTRIENT-RICH ORGANIC SOILS IN BALTIC COUNTRIES?

Hanna Vahter[1], Muhammad Kamil Sardar Ali[1], Thomas Schindler[1], Andis Lazdiņš[2], Ain Kull[1], Ieva Līcīte[2], Ülo Mander[1], Aldis Butlers[2], Jyrki Jauhiainen[3], Dovilė Ciuldiene[4], and Kaido Soosaar[1]

[1]University of Tartu, Tartu, Estonia
[2]Latvian State Forest Research Institute "Silava», Latvia
[3]Natural Resources Institute Finland, Luke, Finland
[4]Institute of Forestry, Lithuanian Research Centre for Agriculture and Forestry, Lithuania

Contact: hanna.vahter@ut.ee

Introduction

Organic soils are one of the largest natural terrestrial carbon stores, mainly in boreal, temperate and tropical wet climate zones. As a common management practice, drainage turns those carbon-rich soils into a significant greenhouse gas (GHG) source. Drainage causes increased carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions due to increased soil mineralization. Methane (CH_4) emissions, on the other hand, are reduced compared to natural wetlands where no soil drainage and tillage are done. Land use, climate zone, soil nutrient status, and drainage status are closely linked to estimating GHG budgets from managed sites on organic soils.
A two-full-year study was conducted to assess the impact of drainage and land use on greenhouse gas fluxes in the Baltic countries. The study was carried out from January 2021 to December 2022. Fluxes with different drainage statuses were determined on 13 sites in 6 groups.

Table 1. Study sites in Estonia (EE), Latvia (LV) & Lithuania (LT) grouped by different drainage statuses

Groups	Site ID	Land use type	Organic layer depth	Water table regime	Water table
(I) Well drained cropland	01EE	Cropland	~35 cm	Drained site	~55 cm
	01LV		~30 cm		~60 cm
	01LT		~45 cm		~60 cm
(II) Well drained grassland	02EE	Grassland	~45 cm	Drained site	~60 cm
	02LV		~50 cm		~60 cm
	02LT		~50 cm		~50 cm
(III) Moderately drained grassland	03EE	Grassland	~35 cm	Drained site	~25 cm
	03LV		~35 cm		~25 cm
(IV) Poorly drained grassland	07EE	Grassland	>1 m	Drained site	~30 cm
	07LT		>2 m		~10 cm
(V) Floodplain fen	10EE	Floodplain fen	>2 m	Naturally wet	~40 cm
(VI) Fen	10LV	Fen	>2 m	Naturally wet	~15 cm
	10LT		>2 m		~10 cm

Our study's **main objective is to calculate a carbon and nitrogen budget and correct GHG emission factors for GHG fluxes** from organic soils in drained croplands and grasslands in the Baltic Countries.

Methodology

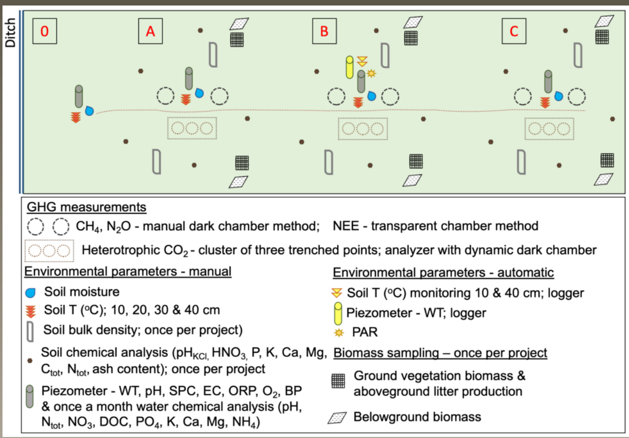


Figure. 1. Plan of the study plot, enclosing three subplots for GHG, environmental parameters (manual & automatic) and biomass samples (figure modified from Jauhiainen *et al.* (2019)).

Results

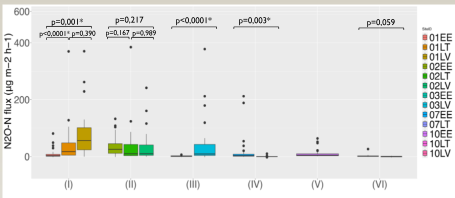


Figure 2. N_2O-N variability and statistical parameters (median, 25th and 75th percentiles, min & max). The y-axis is limited to 600 μg m^{-2} h^{-1} to better observe the dynamics between different subplots in groups. It excludes 12 flux values, reaching up to 8105.6 μg N m^{-2} h^{-1}.

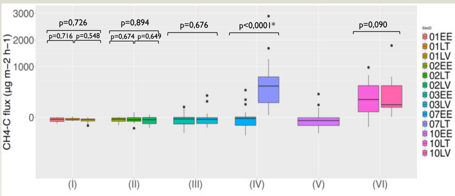


Figure 3. CH_4-C variability and statistical parameters (median, 25th and 75th percentiles, min & max). The y-axis is limited to 3000 μg m^{-2} h^{-1} to better observe the dynamics between different subplots in groups. It excludes 12 flux values, reaching up to 49 635.2 μg C m^{-2} h^{-1}.

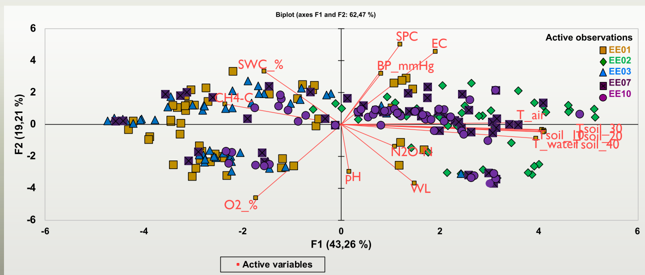


Figure 4. Principal component analysis (PCA) of environmental variables (air T, soil T in four depths, water level (WL), soil water content (SWC), water T, pH, oxygen, electrical conductivity (EC), air pressure (BP)) and N_2O-N & CH_4-C fluxes on five Estonian sites.

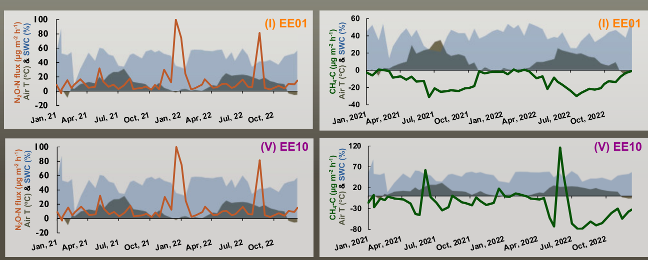


Figure 5. N_2O-N & CH_4-C flux, air temperature & soil moisture (%) seasonal variability examples during the measurement period Jan. 2021–Dec. 2022 in Estonian study sites (I) – cropland & (V) – floodplain fen).

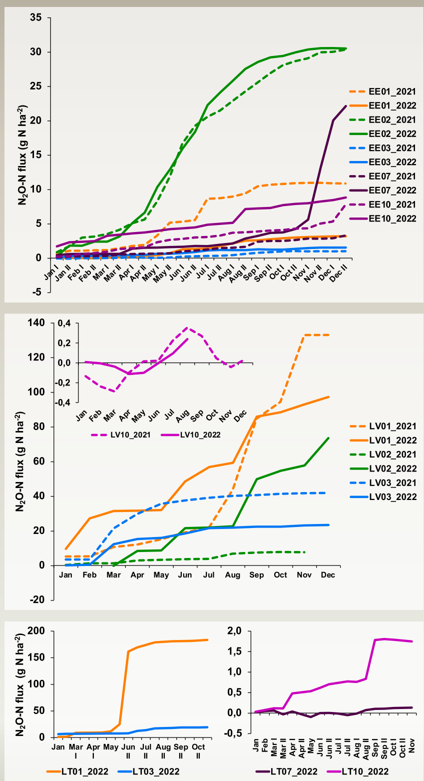


Figure 6. Cumulative N_2O-N fluxes (g N ha^{-2}) in Estonia, Latvia and Lithuania in 2021 and 2022.

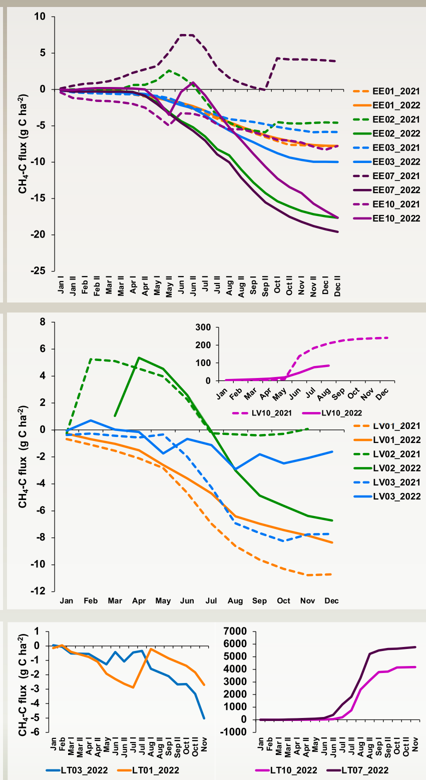
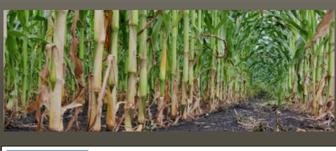
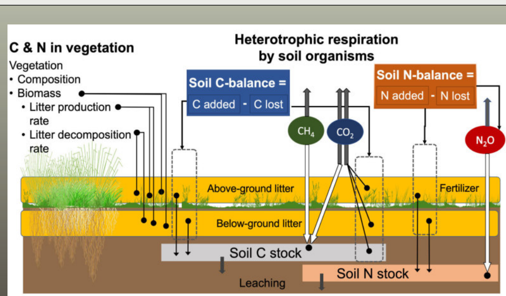


Figure 7. Cumulative CH_4-C fluxes (g C ha^{-2}) in Estonia, Latvia and Lithuania in 2021 and 2022.

Conclusion & next important steps

- High N_2O-N and CH_4-C fluxes variability;
- Well and moderately drained sites (I-III) were annual CH_4-C sinks (emissions varied from -58.27 to 81.66 μg m^{-2} h^{-1}), while fens soils with higher groundwater levels (V, VI) were a source of CH_4-C (fluxes varied from -59.40 to 45 586.6 μg m^{-2} h^{-1});
- All studied sites were annual emitters of N_2O-N (fluxes varied from -2.91 to 3789.57 μg m^{-2} h^{-1});
- Cropland (I) soils were the highest N_2O-N emitters (average flux 75.38±22.54 μg m^{-2} h^{-1}).





- Continue with more in-depth data analysis;
- C and N budget: 1) include heterotrophic CO_2 flux; 2) C and N content in above & below ground biomass; 3) litter and biomass production.