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Response of PPR soils to changing groundwater and salinity: A microcosm study of greenhouse gas emissions

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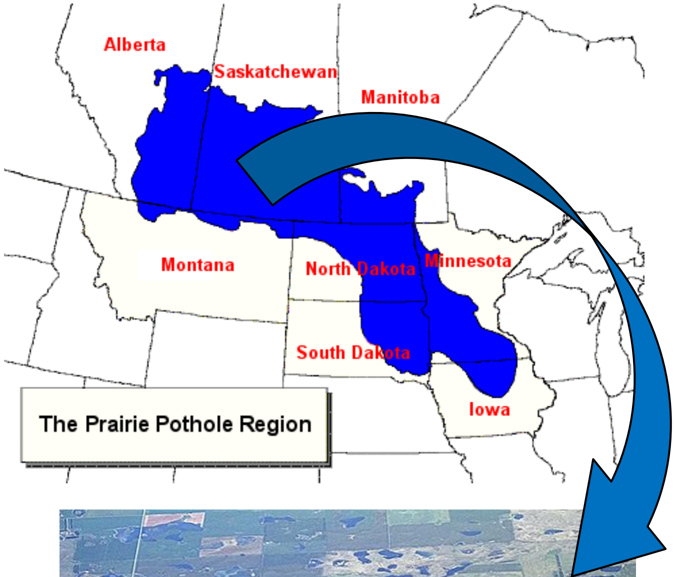
Introduction

- The North American Prairie Pothole Region (PPR) is characterized by relatively small, highly productive, mineral-soil wetlands dispersed throughout the agriculture-dominated landscape.
- Changes in agricultural landuse practices can diminish the capability of the PPR wetland ecosystems and increase the potential of greenhouse gases (GHGs) emissions.



Source: Iowa Learning Farms

Introduction

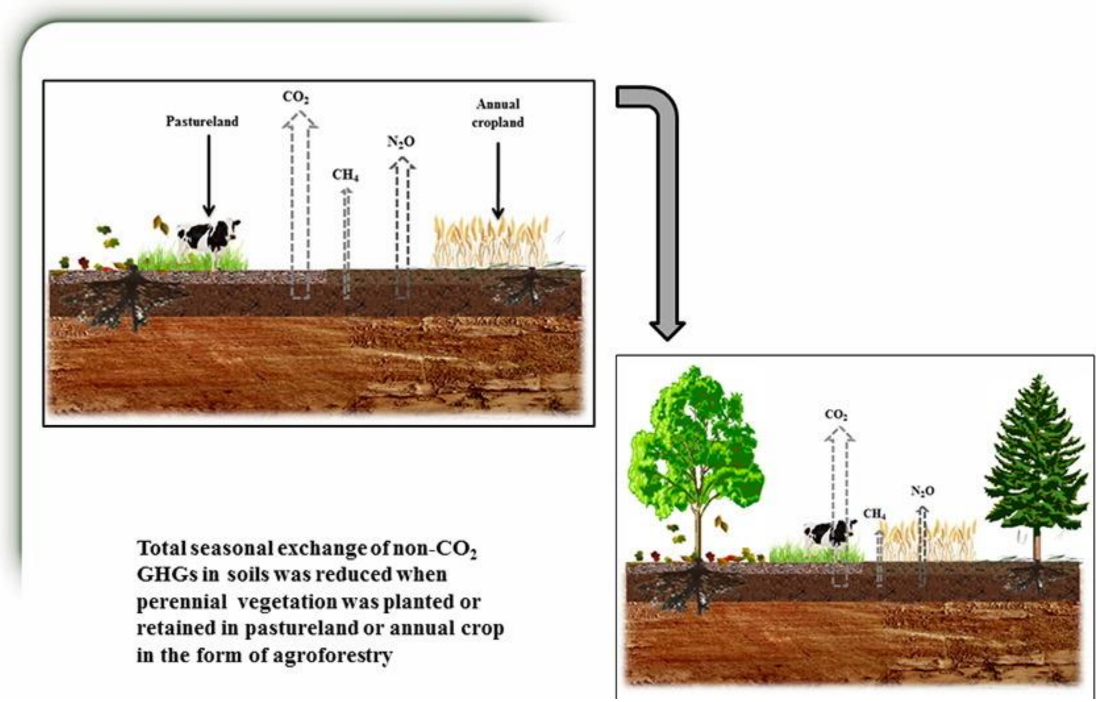
- The greenhouse effect caused by GHGs (CO_2, CH_4, and N_2O) is the main factor of global warming (IPCC, 2013).
- Landuse practices can strongly influence the GHGs emissions (Schaufler et al., 2010; Tangen et al., 2015) in addition to the burning of fossil fuels (Pielke, 2005; IPCC, 2013).
- Production of GHGs in wetland controlled by highly variable abiotic factors e.g. groundwater table, period of inundation, redox conditions and also groundwater salinity (Marton et al., 2012).
- Moreover, landuse practices can have considerable effects on soil processes responsible for regulating GHGs emissions through the makeup of soil microbial and vegetation communities, as well as availability of organic substrates (Tangen et al., 2015).

Introduction

- Landuse practices can also have opposing effects on the production or consumption of GHGs such as CH_4 and N_2O.
- For instance, wetland riparian zones that is drained and cropped likely would have very little CH_4 production because of prevailing aerobic conditions that do not favor methanogenesis;
- However, this same catchment would have a greater likelihood of emitting N_2O due to appropriate soil moisture and agricultural nitrogen fertilizations.

Introduction

- Agroforestry systems and grassland cover types in agricultural lands could reduce emission of non-CO_2 GHGs.
- Therefore, establishment of agroforestry system such as Short Rotation Willow (SRW) in the riparian zones of PPR wetlands can provide benefit to mitigate GHGs.



Source: Baah-Acheamfour et. al. 2016. The science of the total environment 571: 1115-1127.

Introduction

- Riparian zones of wetlands have the potential to contribute significant amounts of GHGs emissions through controlling factors that can be modified by landuse practices (Vidon et al., 2015).
- The change of landuse practices can substantially alter soil organic carbon dynamics and affect emissions of GHGs (Lang et al., 2010).
- Therefore, understanding landuse practices that mitigate GHGs emissions is crucial (Maucieri et al., 2017).
- Furthermore, emissions under variable depths to groundwater table and salinity levels in the riparian zones of Prairie wetland soils with contrasting landuse practices are not well understood and characterized.

Objective

- Examine the effects of landuse practices in the riparian zones of PPR wetland soil under controlled groundwater table and salinity levels.

Research Questions

Are there any differences in GHGs emissions

→ between sites (low background soil salinity vs high)?

→ among three landuse practices (SRW, AC and P)?

→ between groundwater salinity levels (lower vs higher salinity treatments)?

Materials and Methods

- Intact soil cores (30cm depth) were collected from mid slope position of PPR wetland riparian zones from Indian Head, SK.

- Short Rotation Willow (*Salix dasyclados* Wimm. 'India') was cultivated side by side with pasture and oats as annual crop.
- The pasture remained unmanaged for last 10-12 years with established vegetation of alfalfa and brome grass mixture.

Materials and Methods

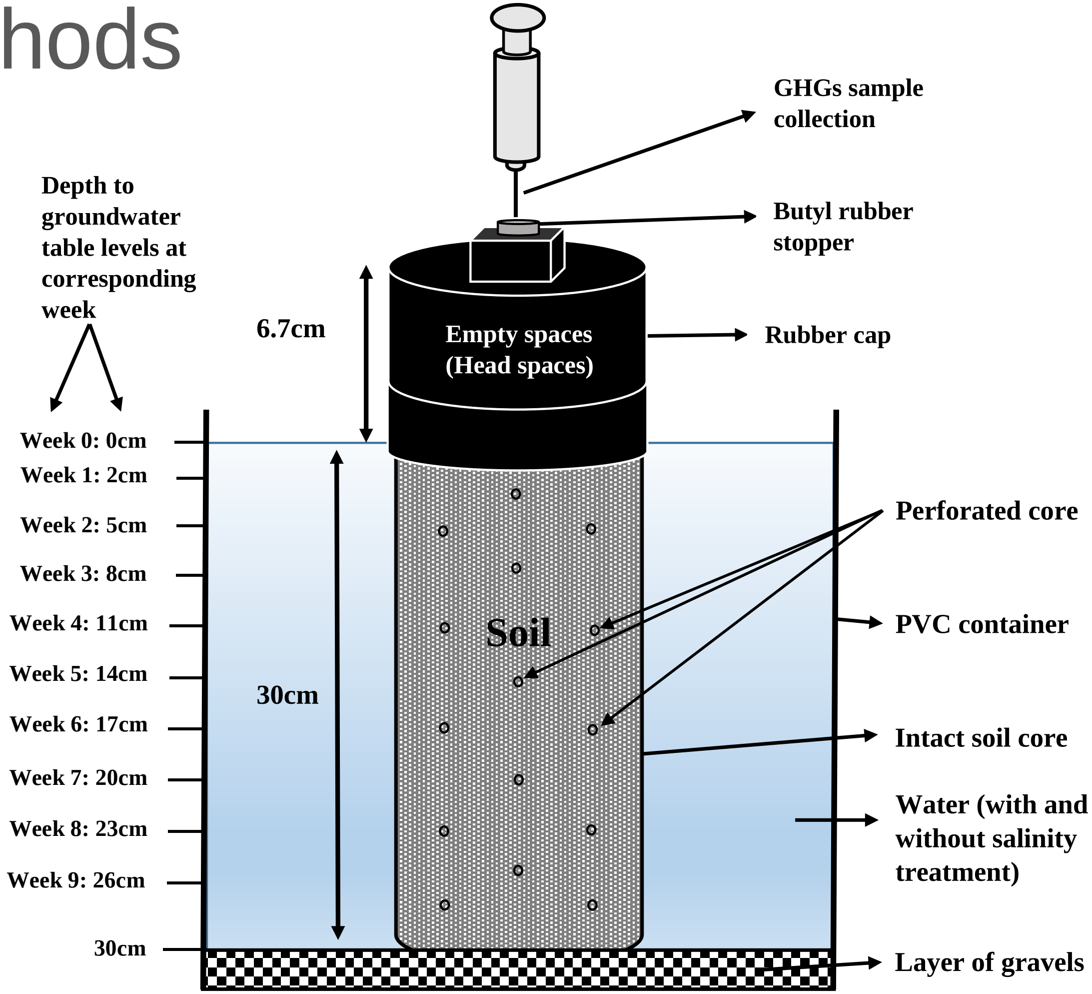
- Factorial experimental design was used with three main factors:
  - Soils from 2 sites Site A and Site B
  - 3 adjacent landuse practices (i.e. SRW = Short Rotation Willow; AC = Annual Crop; and P = Pasture)
  - 3 groundwater salinity treatments S0 = Control (0.3mS cm^{-1}), S1 = 6 mS cm^{-1}, S2 = 12 mS cm^{-1}
- With 3 replications
- There were 9 weeks of GHGs (CO_2, CH_4, N_2O) measurements with their corresponding groundwater table depth in 3cm decrements in each week.
- The incubation temperature was controlled between 22-24^oC

Materials and Methods

- Groundwater salinity treatments with Na_2SO_4 : KCl : $CaCl_2$: $MgSO_4$ salts.
- Volumetric water content and soil electrical conductivity were also measured weekly during the GHGs sampling.

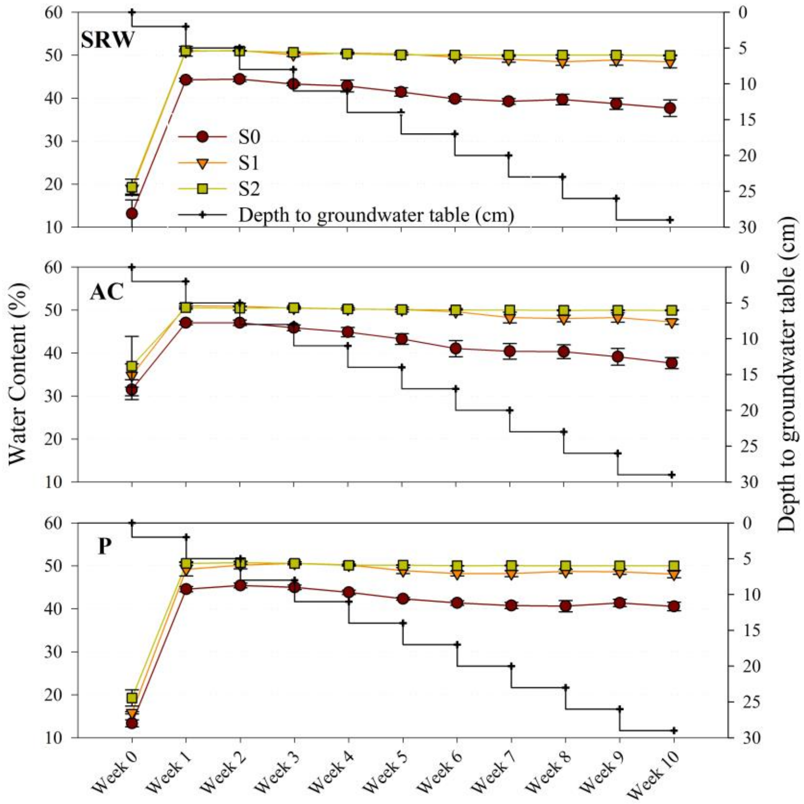
Materials and Methods

Illustration of an individual experimental unit with intact soil core used for microcosm study (Note: diagram is not to scale)

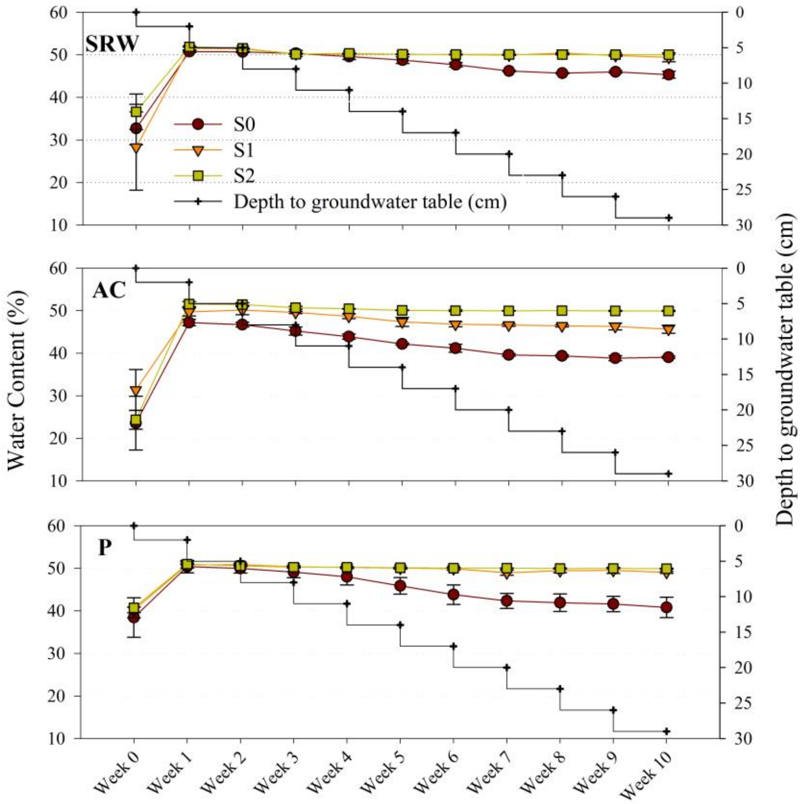


Results

Site A

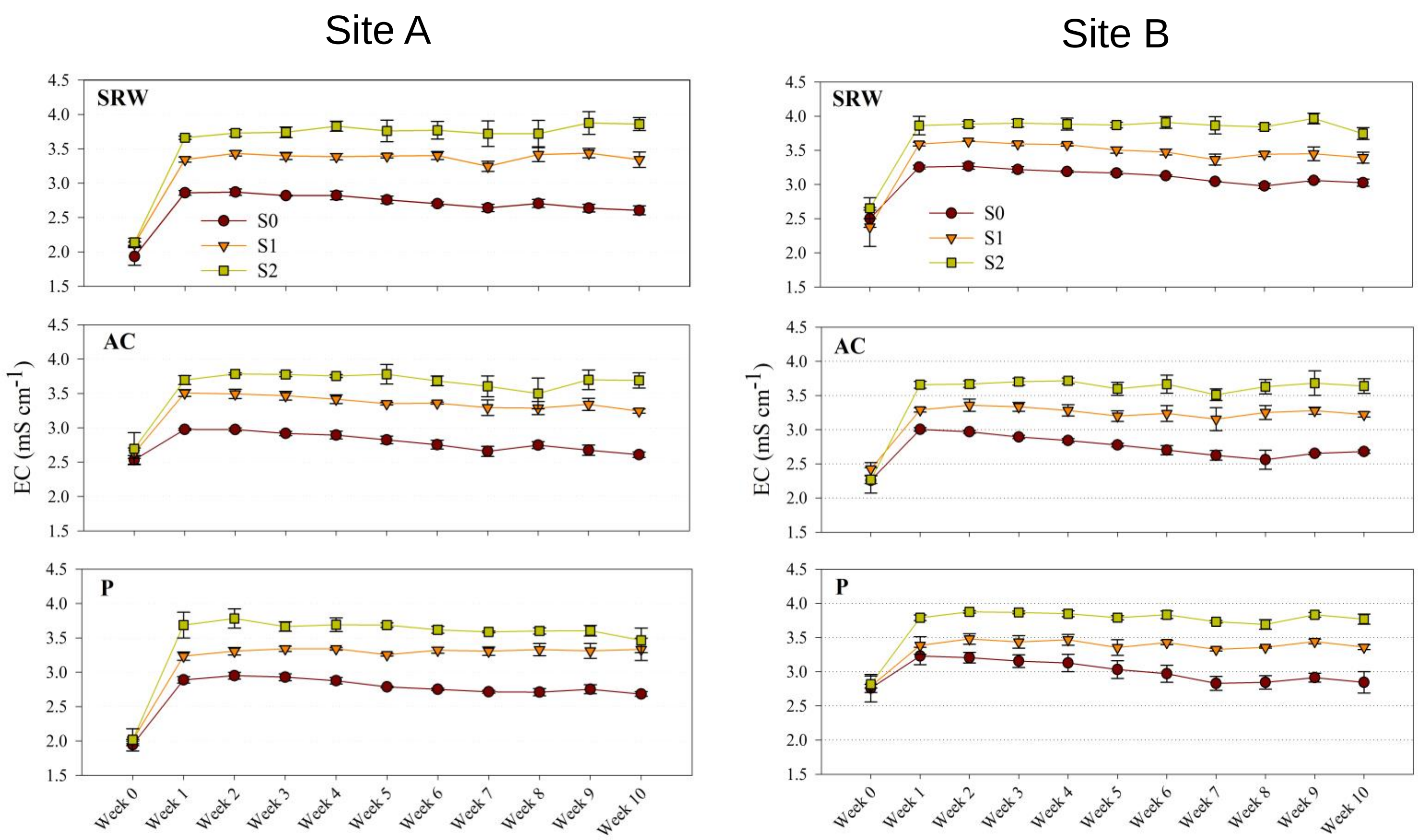


Site B



Soil Moisture measured in cores over the incubation period

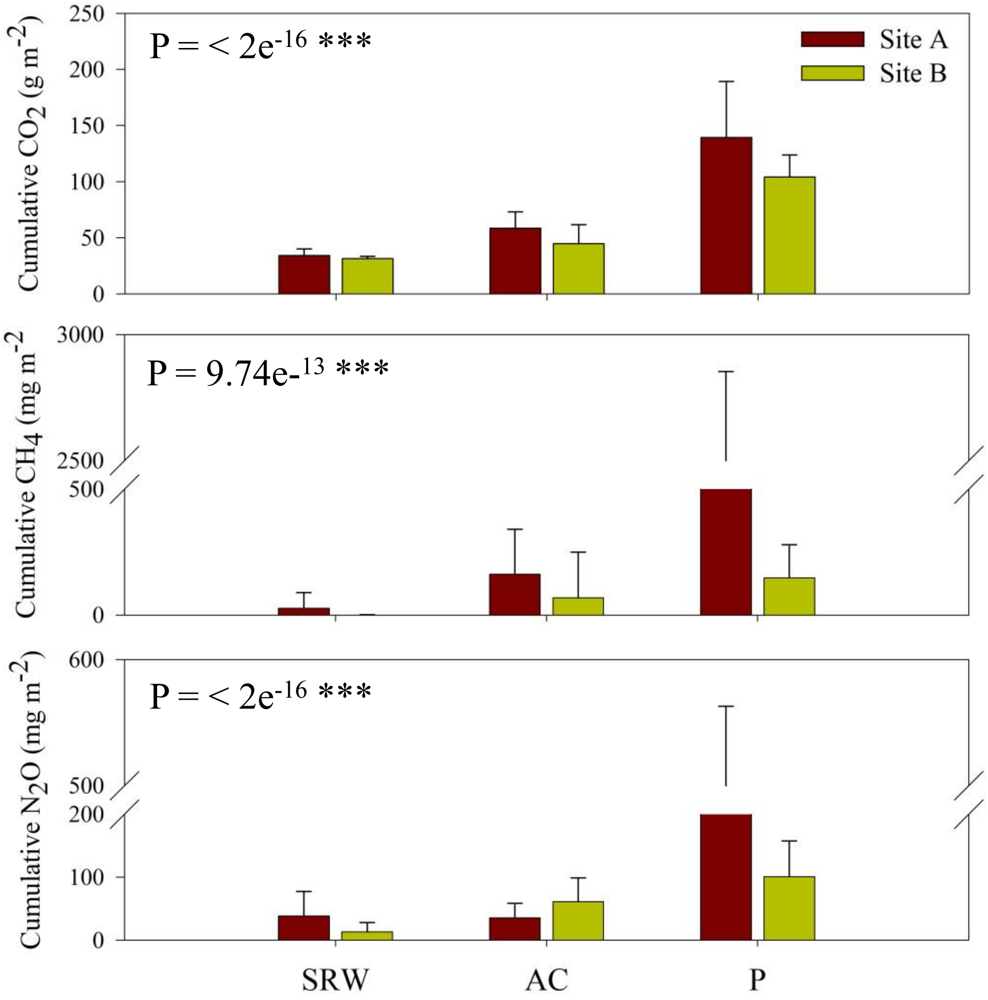
Results



Soil Electrical Conductivity (EC) measured in cores over the incubation period

Results

Cumulative GHGs emissions from soils under different landuse practices



SRW = Short Rotation Willow
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Results

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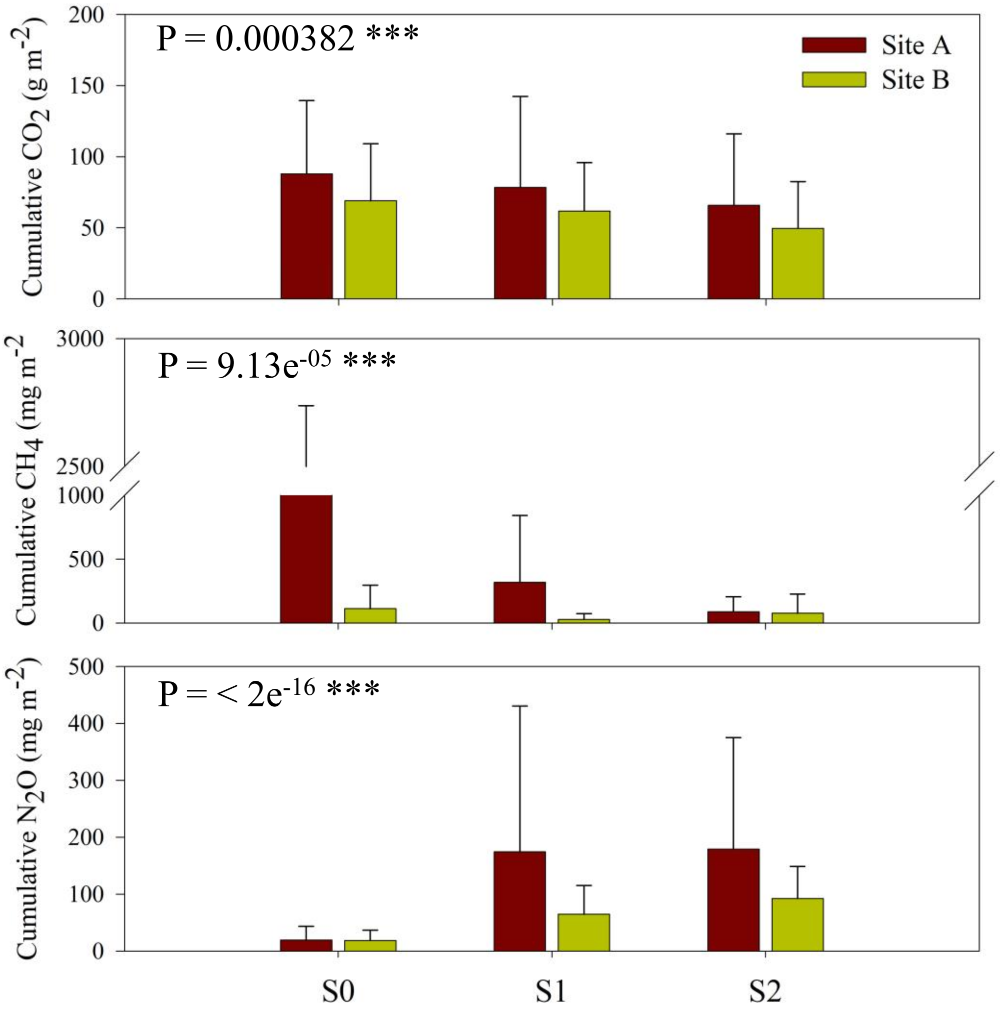
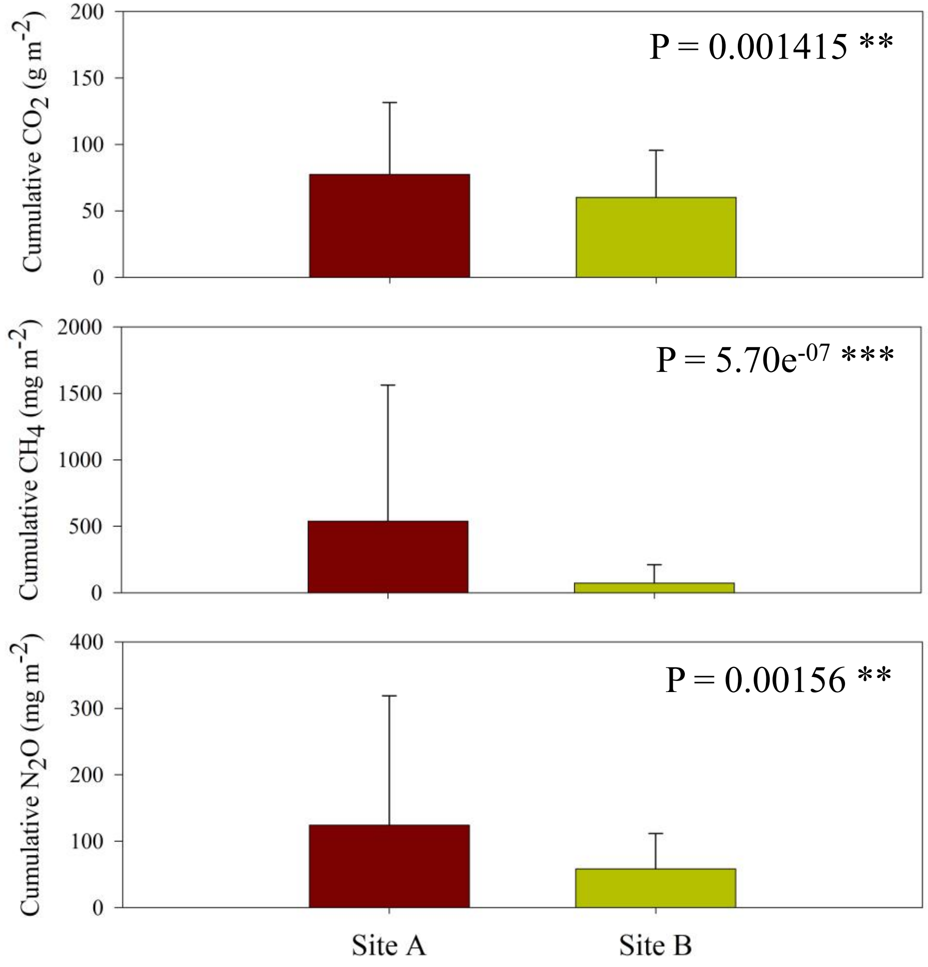


Results

Cumulative GHGs emissions from soils from different sites

A = Site 1 (lower background soil salinity)
B = Site 2 (higher background soil salinity)



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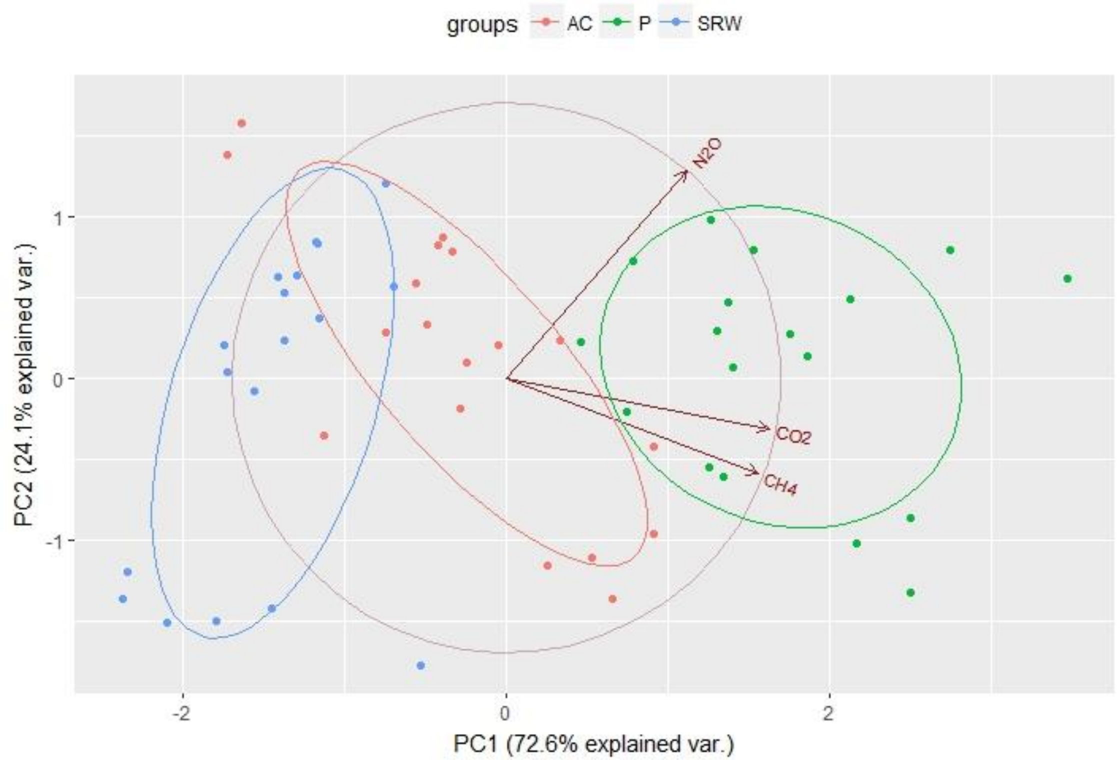

	PC1	PC2	r2	Pr(>r)
LanduseAC	-0.85416	0.52002	0.0198	0.622
LanduseP	0.99754	0.07016	0.6766	0.001 ***
LanduseSRW	-0.98297	-0.18375	0.5076	0.001 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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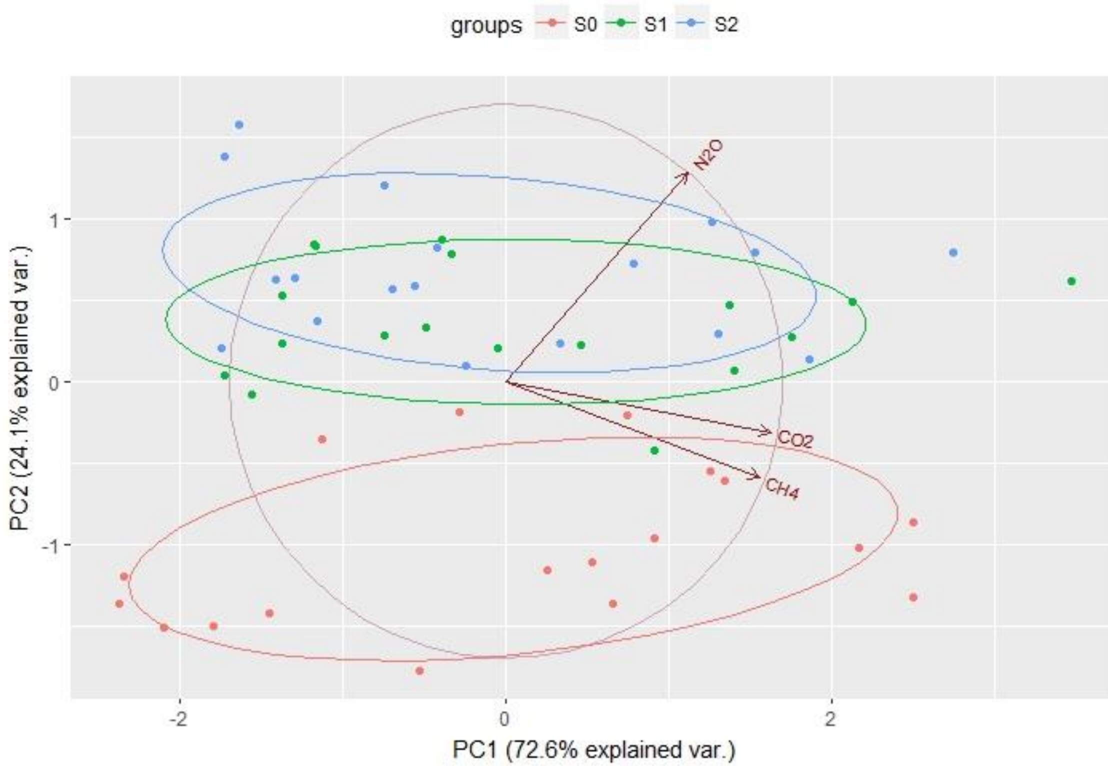

	PC1	PC2	r2	Pr(>r)
SalinityS0	0.024923	-0.999690	0.7463	0.001 ***
SalinityS1	0.094476	0.995530	0.0940	0.078 .
SalinityS2	-0.090085	0.995930	0.3143	0.001 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

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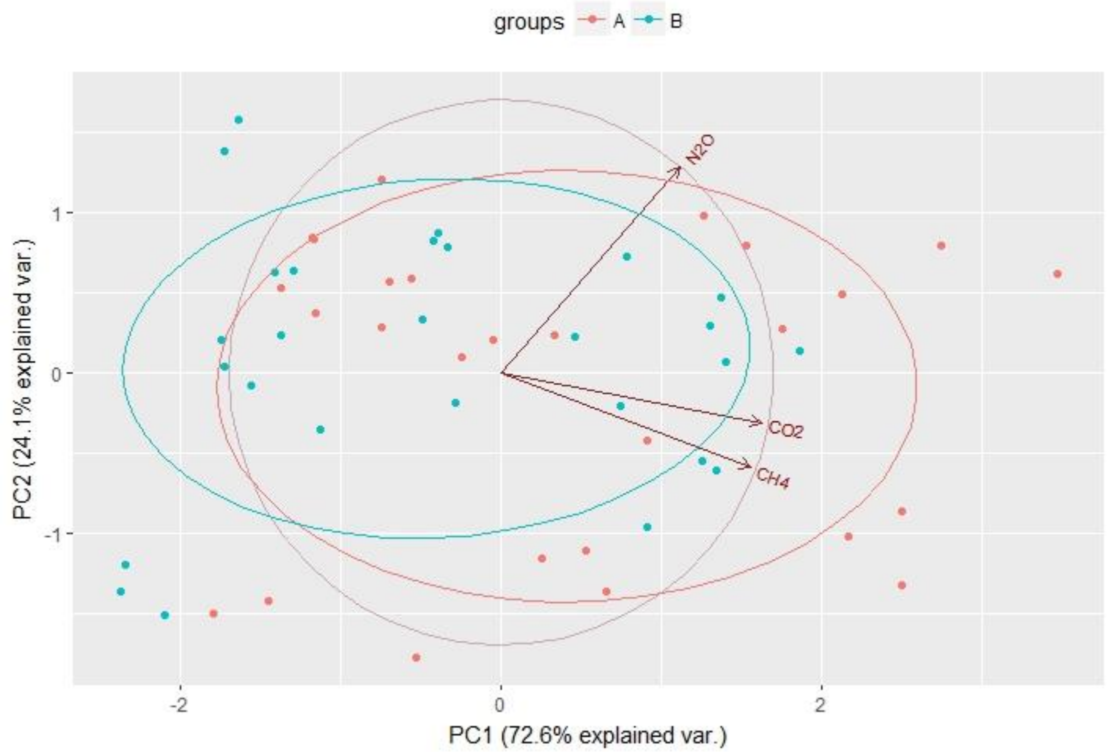

	PC1	PC2	r2	Pr(>r)
SiteA	0.93787	-0.34699	0.0879	0.099 .
SiteB	-0.93787	0.34699	0.0879	0.099 .

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Conclusion

- Cumulative GHGs emissions were significantly different among the landuse practices, salinity levels and sites.
- Regardless of site, significantly higher cumulative CO_2, CH_4 and N_2O emissions were found from pasture soils, followed by annual crop and short rotation willow.
- CO_2 and CH_4 emissions were significantly higher in control salinity treatment, whereas N_2O emission was significantly higher under elevated salinity treatment (12 mS cm^{-1}).
- Higher cumulative GHGs emissions were found in soils from site A which has relatively lower background salinity levels (in terms of both initial and measured during incubation period) than site B.

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