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Greenhouse gas emissions from septic systems

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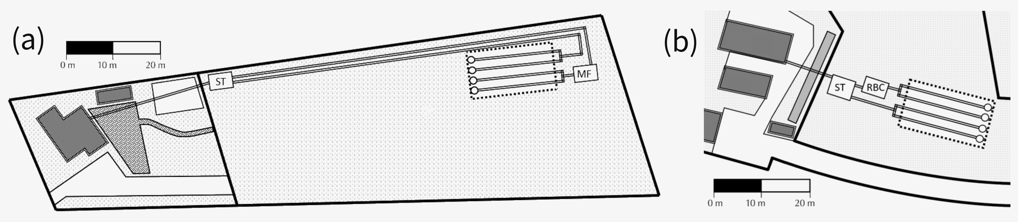
1 Context

Wastewater treatment is contributing approximately 40% of total waste related GHG emissions globally.[1] These estimations, however, are based on a limited number of case studies from mostly centralized systems and considered highly uncertain.

Despite an estimated 20% of the population in the US and EEA relying on on-site wastewater treatment and disposal,[2,3] only a limited number of studies, so far, have been conducted using direct measurements of GHG emissions from OWTSs.[4-9]

2 Research Sites

Two sites were constructed in Co. Limerick. Septic tank effluent was equally split, such that half of the STU received PE and the other half received SE.



↑Fig 1: OWTS layout with effluent splitting after ST at (a) Site A and (b) Site B.

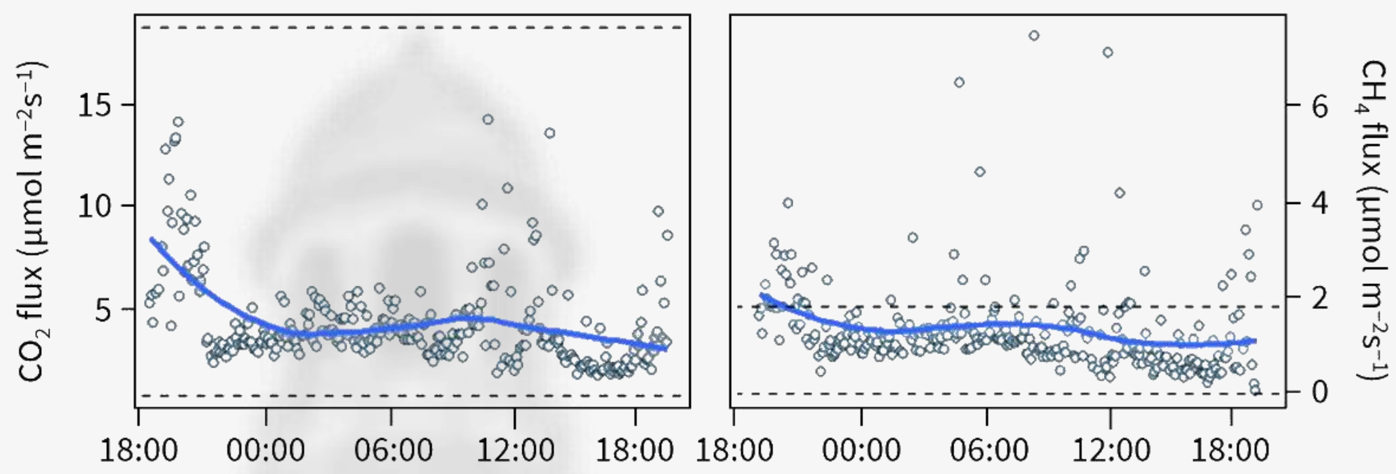
↓Tab 1: Overview of soil physical parameters and OWTS design for both sites

	Site A	Site B
subsoil	sandy loam	sandy silt loam
K_{sat}	32.3 cm d^{-1}	13.9 cm d^{-1}
construction	Sep 2015	Apr 2016
primary unit	septic tank	septic tank
secondary unit	cocopeat filter	RBC
conveyance	pumped	gravity flow

3 Results

Emissions from the Septic Tank

GHG emissions measured directly on the ST surface express diurnal variations and show high emission peaks caused by ebullitive events that might not be detected with non-continuous, discrete measurements.

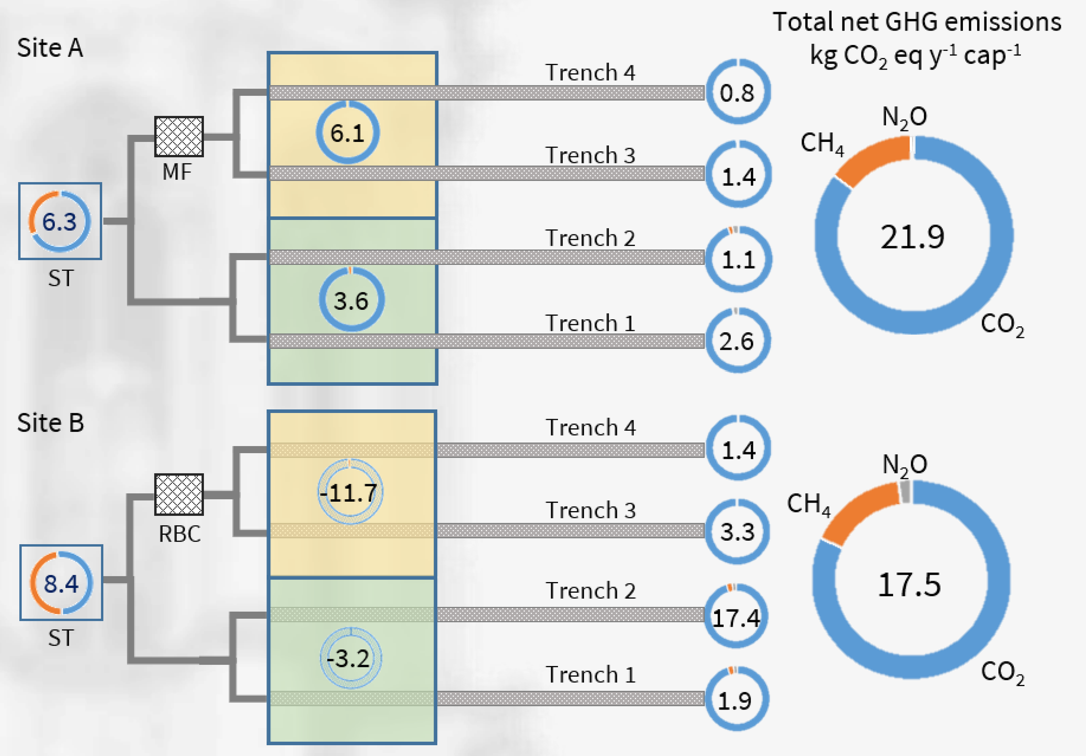


↑Fig. 4: Diurnal variation of CO2 and CH4 fluxes from the ST second chamber in Site A. Dashed lines indicate minimum and maximum fluxes observed during discrete one-off sampling.

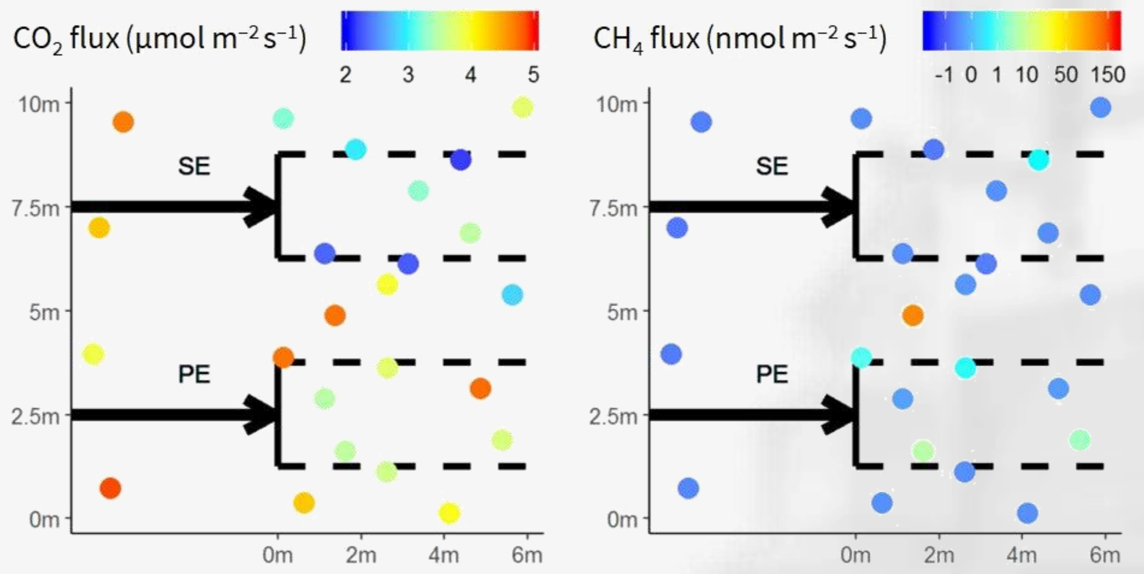
Emissions from the Soil Treatment Unit

Net annual GHG emissions varied widely across sites. While Site A expressed a net release of GHGs over the STU, Site B showed a net uptake. The vent in trench 2 (Site B), which was covered with a mature biomat,[10] accounted for the majority of emissions from that site, indicating that extensive biomat growth can affect overall emissions.

Fig. 5: Overview of net emissions (expressed as CO_2 eq) from both systems → consisting of ST, STU and vent system. PE was fed into trenches 1 and 2; trenches 3 and 4 received SE.



Generally, higher CO_2 and CH_4 emissions were observed over trenches receiving PE as compared to trenches receiving SE. However, in Site B overall emissions from the STU were lower than over control soil, but higher from the vent system as compared to Site A.



↑Fig. 6: Spatial variation of mean of CO_2 and CH_4 emissions in Site B.

3 Methodology

- Long-term and survey measurements were performed for a period of 14 months using randomized locations within the first 6 m of the STU
- Emissions from the liquid surface of the ST were measured using fixed floating chambers in both ST compartments
- Vent system emission were determined by measuring gas concentrations in the capped vent until a steady-state was reached

↑Fig. 3: Measurements on ST surface & vent system

↓Fig. 2: Automated soil gas flux chambers over the STU

- CO_2 and CH_4 fluxes were determined from continuous measurements of chamber gas concentrations using on-site gas analysers (LI-COR 8100A + Los Gatos Ultraportable)
- N_2O fluxes were determined from discrete gas samples (n = 4) taken for GC analysis in the lab

4 Conclusions

- Emissions of GHGs from OWTS vary significantly across time and system component
- Measurements of GHG emissions from OWTS should be temporally and spatially integrated
- While STUs produce the majority of CO_2, the ST is the main source of CH_4 and the vent of N_2O
- Further research should be focussed on understanding the environmental, anthropogenic, soil-physical and microbial drivers of GHG production and conversion in OWTS

5 References & Abbreviations

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(9) Somlai et al., 2019. Sci Total Environ, 679:185-195
(10) Knappe et al., 2019. (submitted for publication)

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Abbreviations: *EEA* (European Economic Area), GC (gas chromatography), GHG (greenhouse gas), K_{sat} (saturated hydraulic conductivity), MF (media filter), OWTS (on-site wastewater treatment system), PE (primary effluent), RBC (rotating biological contactor), SE (secondary effluent), ST (septic tank), STU (soil treatment unit)

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