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The University of Dublin

Tracing biomass growth in soil treatment units using a network of automated soil sensors

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Context

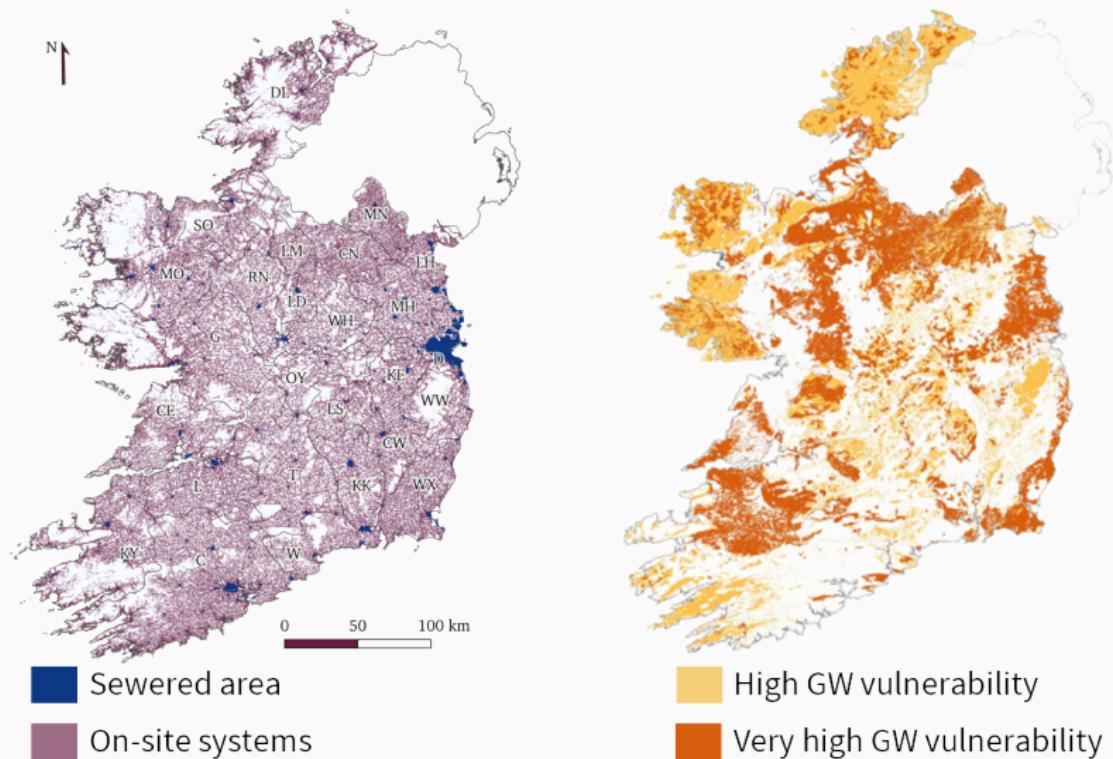
Context – On-site sanitation in Ireland (I)



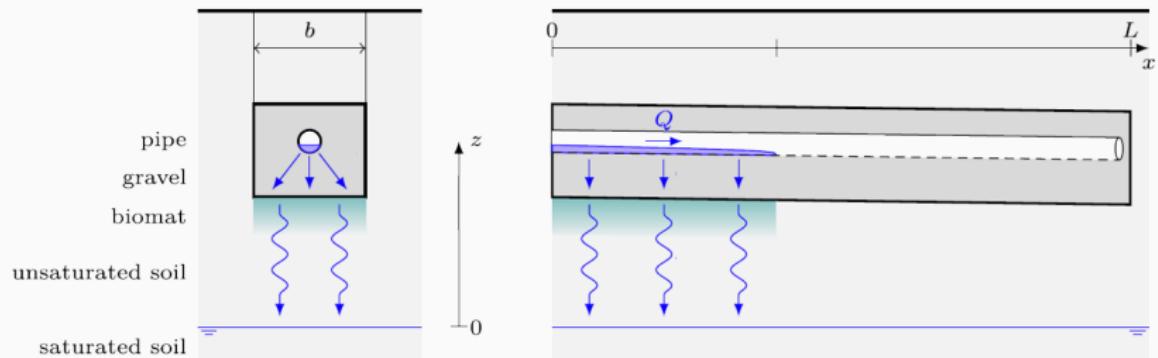
Context – On-site sanitation in Ireland (I)



Context – On-site sanitation in Ireland (II)



Context – Biomat development in percolation trenches



Biomat spread in percolation trench receiving effluent (Winstanley & Fowler, 2013)

How does pre-treatment influence biomat growth?

Study design

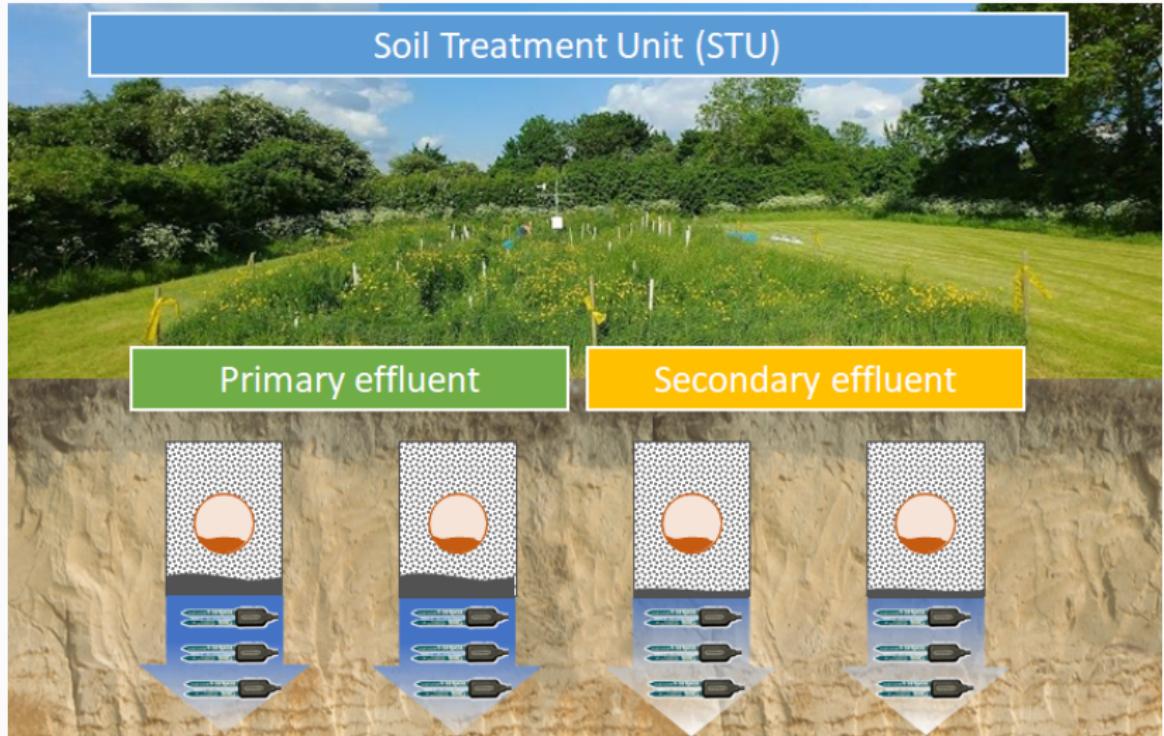
Study design – Locations



Site construction – STU trenches



Site construction – Sensor installation (I)



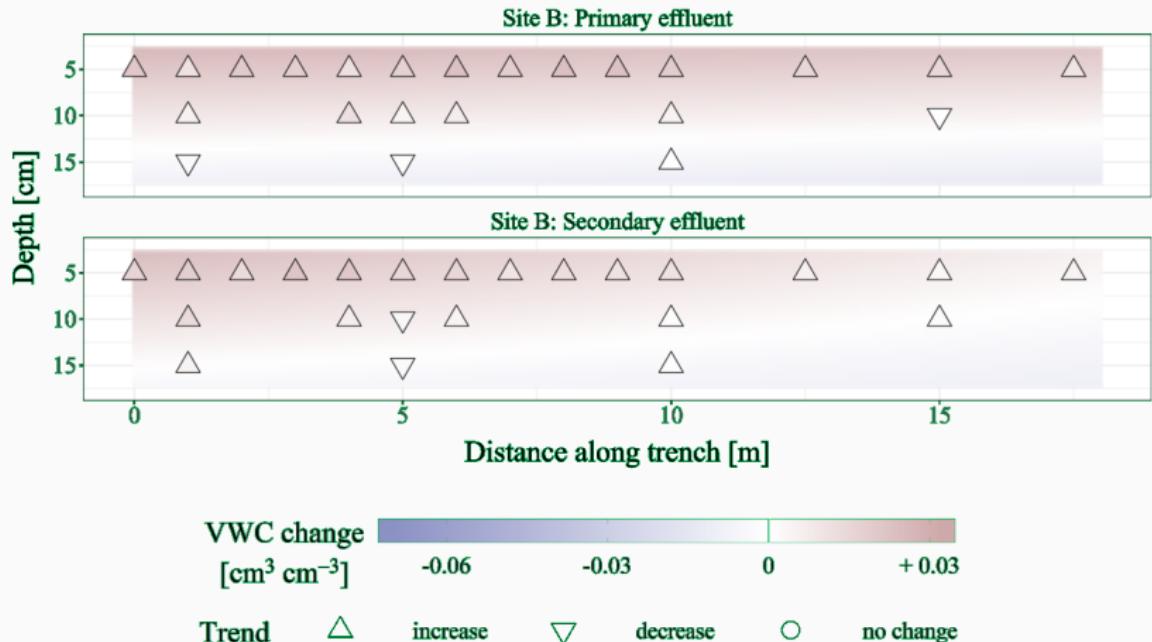
Site construction – Sensor installation (II)



Installation of Decagon EC5 soil sensors below the infiltrative surface to monitor changes in soil water content at various depths

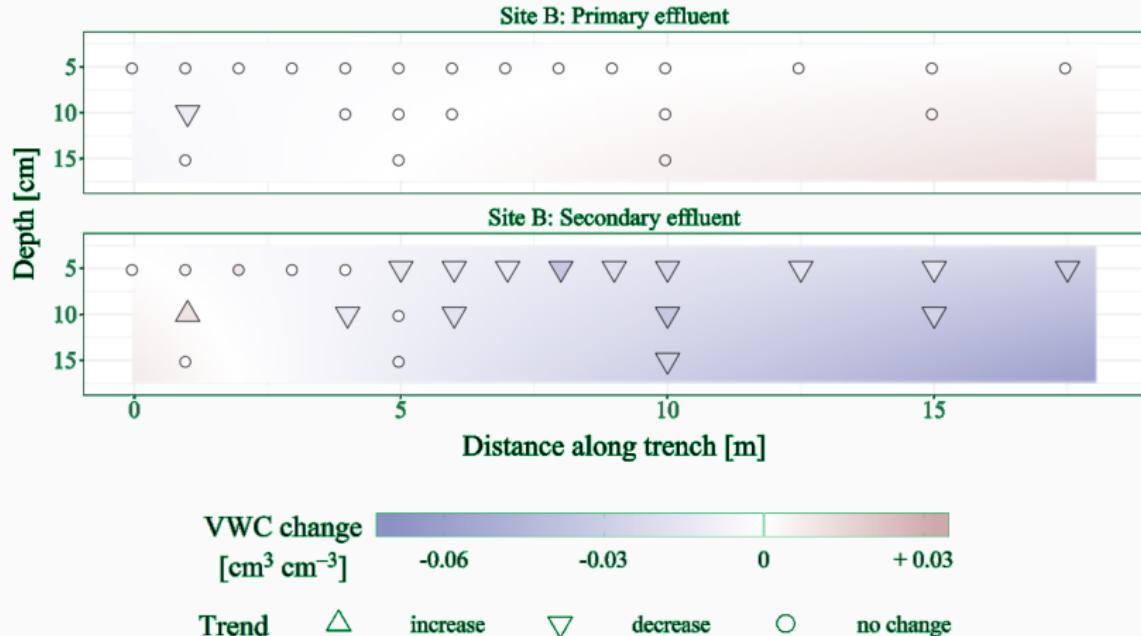
Results

Results – Increasing water retention



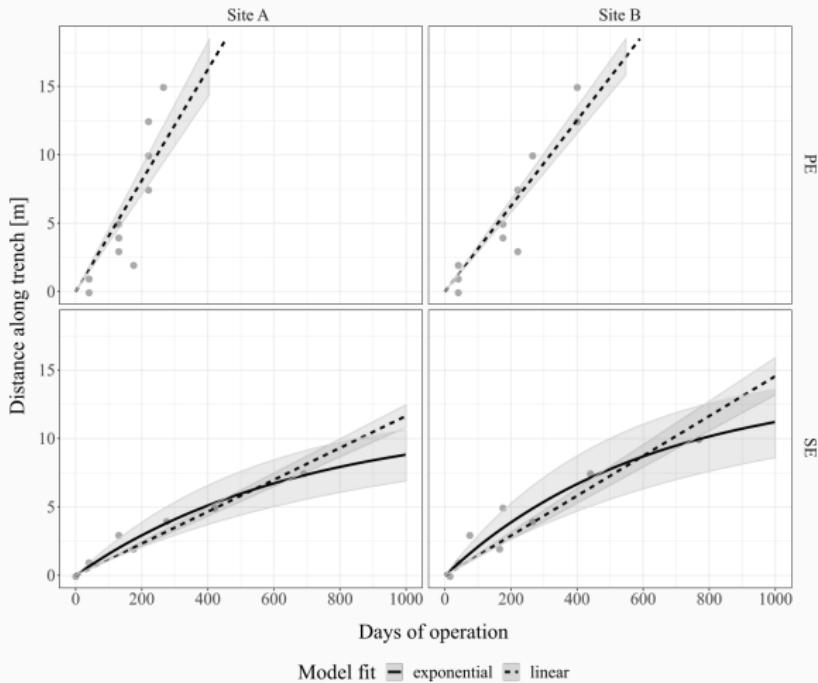
Increasing water retention over 2 years of operation

Results – Hydraulic barrier during drought



Hydraulic barrier effect during drought in summer 2018

Results – Clogging Rate (I)



Time to reach persistent 2.5 % increase in VWC over background level

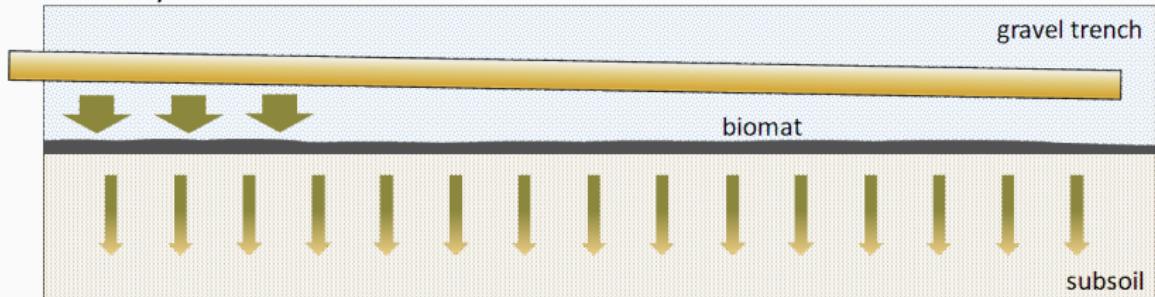
Results – Clogging Rate (II)

Results of linear and growth-limited exponential model fit for clogging rates. Linear: $I_{\text{biomat}} = r_c t$; exponential: $I_{\text{biomat}} = I_{\text{ss}}(1 - \exp(-\mu t))$.

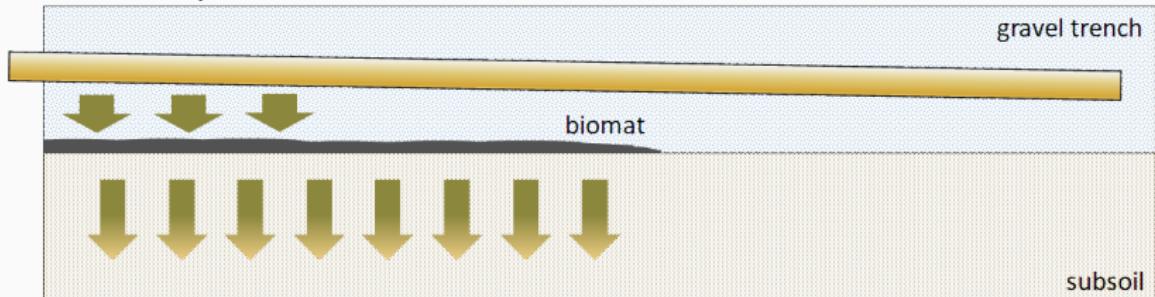
Site	Effluent	Modela	Coefficients
CC	PE	linear	$r_c = (3.13 \pm 0.24) \times 10^{-2} \text{ cm d}^{-1}$
	SE	linear	$r_c = (1.46 \pm 0.14) \times 10^{-2} \text{ cm d}^{-1}$
		exponential	$I_{\text{ss}} = 13.95(165) \text{ m}$
			$\mu = (1.49 \pm 0.34) \times 10^{-3} \text{ d}^{-1}$
KM	PE	linear	$r_c = (4.06 \pm 0.50) \times 10^{-2} \text{ cm d}^{-1}$
	SE	linear	$r_c = (1.17 \pm 0.08) \times 10^{-2} \text{ cm d}^{-1}$
		exponential	$I_{\text{ss}} = 11.41(127) \text{ m}$
			$\mu = 1.63(42) \times 10^{-3} \text{ d}^{-1}$

Results - Biomat growth vs. load

Primary effluent



Secondary effluent



Conclusions

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- VWC can be used to track biomat growth
 1. increasing water retention
 2. formation of a protective biomat layer at the infiltrative surface
 3. response to environmental conditions
- Data improves mathematical models of biomat growth
- Further validation needed
 1. in relation to pore water quality data and soil type
 2. microbial composition of biomat
 3. effects on GHG emissions

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GHG emissions from septic systems



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Greenhouse gas emissions from septic systems

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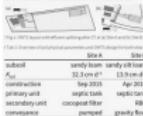
1. Context

Wastewater treatment is contributing significantly to total climate related greenhouse gas (GHG) emissions. These assessments are based on a limited number of case studies, from mostly centralized systems and considered highly uncertain.

Based on a review of 20% of the papers in the US and EU relating to GHG emissions from wastewater treatment and disposal, only a limited number of studies, so far, have been conducted using direct measurement of GHG emissions from STUs.^{1,2}

2. Research Sites

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



3. Methodology

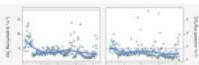
- Long-term and steady measurements were performed for a period of 14 months using standardized locations within the first 6 m of the STU.
- Direct measurements of the fluxes were measured using Need-Routing chambers (in both ST components).
- Wet system emissions were determined by measuring gas concentrations in the capture vent until a steady state was reached.



3. Results

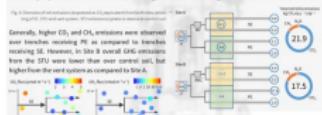
Emissions from the Septic Tank

Fig. 1 shows the seasonal variation on the ST surface. Express, thermal variations, and show high emission rates caused by adverse events that might not be detected. Non-continuous, discrete measurements.



Emissions from the Soil Treatment Unit

Fig. 2 shows the seasonal variation of GHG emissions from the STU. Site A expressed a net uptake, while Site B showed a net uptake. The rate in trench 2 (Site B), which was covered with a mulch layer, P³, accounted for the majority of emissions from that site, indicating the environmental growth can affect overall emissions.



4. Conclusions

- Emissions from STUs vary significantly across time and system component.
- Measurements of GHG emissions from STUs are difficult due to the complex design and layout.
- While STUs produce the majority of CO₂, the ST is the main source of CH₄ and the wet P,D.
- The results highlight the importance of understanding the environmental, anthropogenic, soil physical and microbial drivers of GHG production and consequences on GHG.

5. References & Acknowledgements

- CO₂ and CH₄ fluxes were determined from concentration measurements of atmospheric gases using on-site gas analysers (IRGA) and gas samples (gas flux chamber) taken for GC analysis in the lab.



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Session 380

Soil-Based Wastewater Treatment: Impacts and Mechanisms Poster

Poster 1253

4:00 PM - 6:00 PM

Exhibit Hall 1

Tracing biomat growth in soil treatment units using a network of automated soil sensors

Thanks to all the helping hands:



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For what's next

Appendix

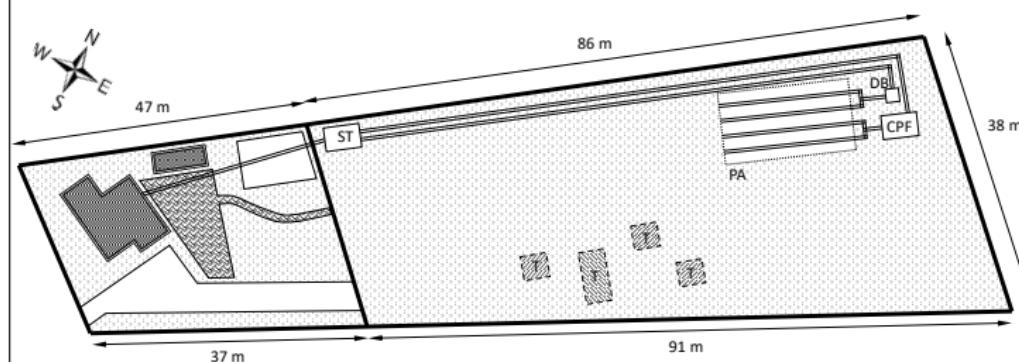
Appendix – Site characteristics

	Kilmallock	Crecora
population equivalent	4	4
subsoil	sandy loam	clay loam
K_{fs}	30.9 cm d^{-1}	13.9 cm d^{-1}
construction	September 2015	April 2016
secondary treatment	Ecoflo media filter	Biodisc RBC
conveyance	pumped flow	gravity flow

Appendix – Kilmallock



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Key

Building	Trial Hole	CPF	Cocopeat Filter
Paved Area	T-test Hole	PA	Percolation Area
Road	DB	Distribution Box	Sewer Line
Unpaved Area	ST	Septic Tank	

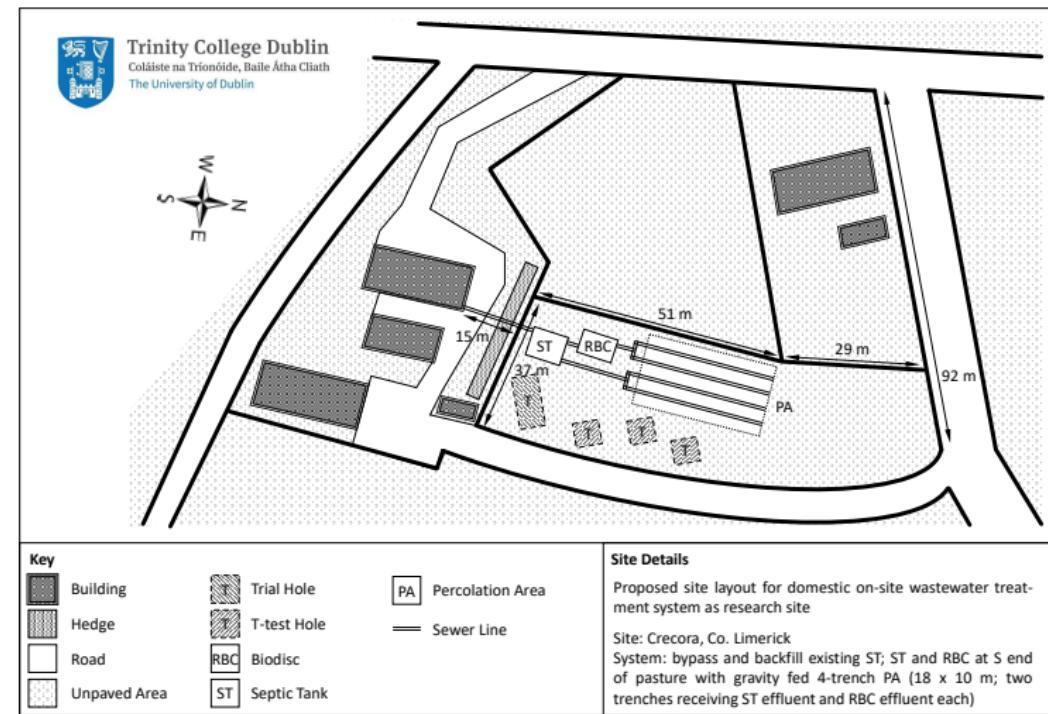
Site Details

Proposed site layout for domestic on-site wastewater treatment system as research site

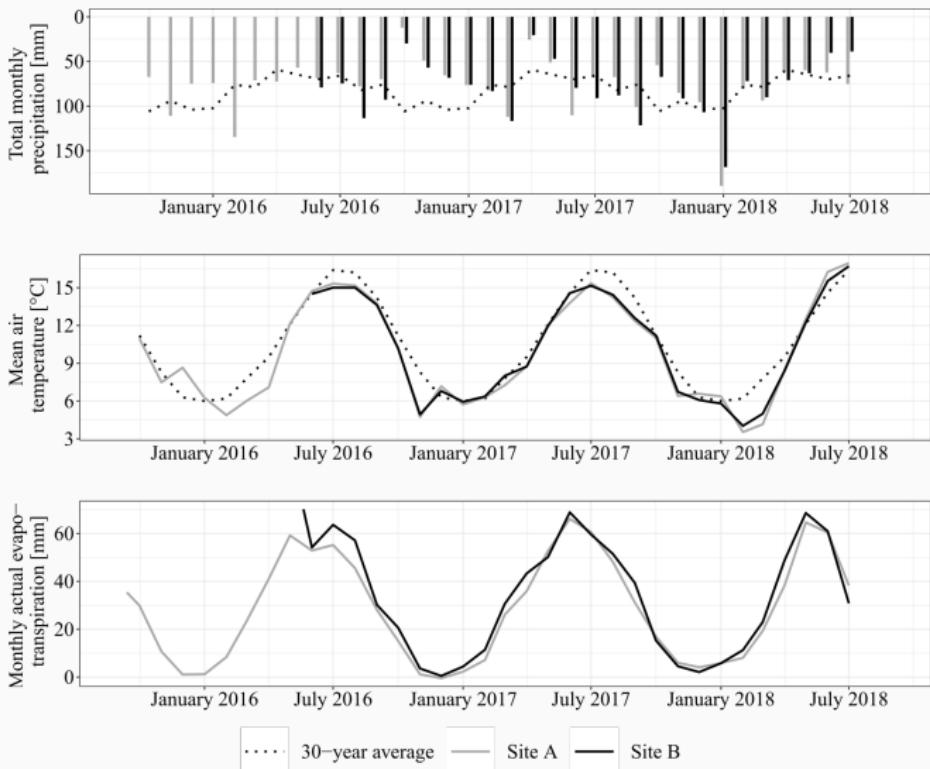
Site: Kilmallock, Co. Limerick

System: ST at location of existing leach field with dual pumped effluent pipe; CPF at NE end of property with gravity fed 4-trench PA (18 x 10 m)

Appendix – Crecora



Appendix – Weather data



Appendix – Effective hydraulic conductivities

Results of constant-head permeameter tests for determining the field saturated hydraulic conductivity K_{fs} of the undisturbed subsoil and the effective saturated hydraulic conductivity K_{eff} at the base of percolation trenches receiving primary (PE) and secondary effluent (SE) after 1080 d and 860 d of operation for Site A and Site B, respectively.

Site	K_{fs} cm d^{-1}	Effluent type	$K_{eff}^{(1\text{ m})}$ cm d^{-1}	$K_{eff}^{(8\text{ m})}$ cm d^{-1}	$K_{eff}^{(12.5\text{ m})}$ cm d^{-1}
Site A	30.9	PE	9.7	12.1	
		SE	3.2	32.1	
Site B	13.9	PE	3.1		4.0
		SE	12.5	11.3	