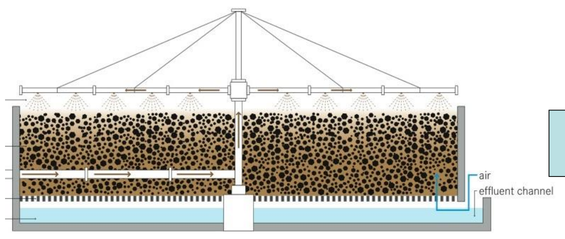
Microtopographic enhancement of soil-based wastewater treatment systems.

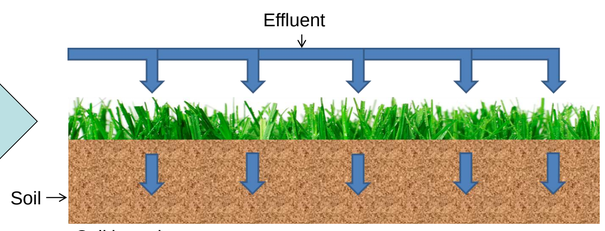
Sean R. Tyrrell
Academic supervisors: Dr. Tim Hess & Dr. Sean Tyrrel
Industrial supervisor: David Knaggs

Cranfield UNIVERSITY

Soil-based wastewater treatment



Secondary treatment trickling filter http://www.sswm.info



Soil based treatment system

Water treatment processes
Assimilation of: NH_4, NO_3 and PO_4
Mineralisation: Organic N to NH_4 and organic P to PO_4
Nitrification/denitrification
Adsorption: NH_4 and PO_4
Precipitation of: PO_4

Secondary treated wastewater is used to irrigate a vegetated plot. The wastewater infiltrates into the soil and is treated by processes within the plant-soil-water matrix. The level of treatment is dependent upon a number of factors including loading and soil conditions.

Enhancing microtopography

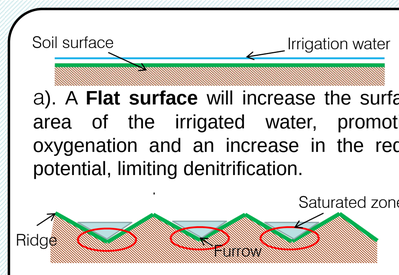
- **Microtopography (MT)** is *'soil surface variation within an elevation range from 1cm to 1m'* (Bledsoe & Shear, 2000)
- By increasing the MT of a soil-based treatment system, conditions and processes within the soil are influenced
- The aim of this project is to determine whether increasing the MT positively benefits soil-based treatment systems
- Potential benefits are not limited to water treatment potential, but also includes the value of the system as an ecosystem
- The theory behind two potential benefits resulting from enhancing MT are given to the left

Microtopography enhanced by ridge and furrowing

Theory behind potential increased denitrification

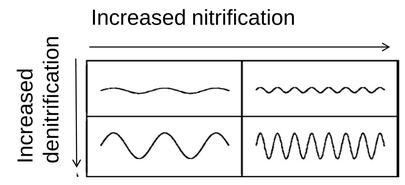
NO_3^-
↓
Denitrification ← Requires low redox potential, carbon source and denitrifying bacteria
↓
N_2

Treated wastewater rich in nitrate



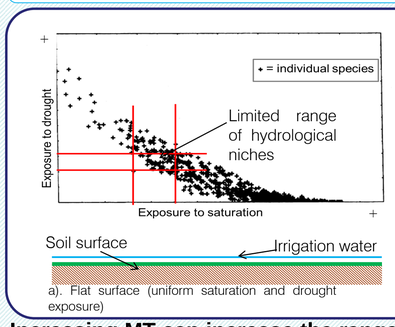
a). A **Flat surface** will increase the surface area of the irrigated water, promoting oxygenation and an increase in the redox potential, limiting denitrification.

b).**Increased MT** creates saturated furrows where redox potential is reduced and organic matter (a carbon source) is accumulated, promoting denitrification.

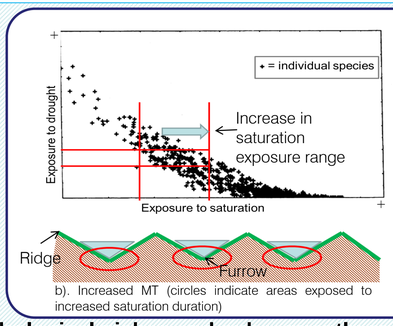


Hypothetical effect of MT upon N cycling (Wolf *et al*. 2011).

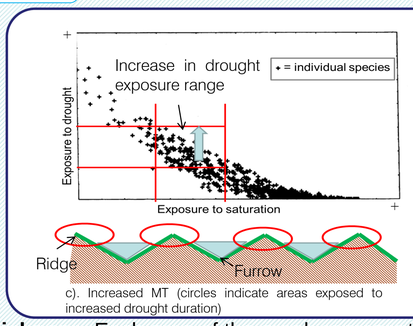
Theory behind potential increased vegetation species richness



a). Flat surface (uniform saturation and drought exposure)



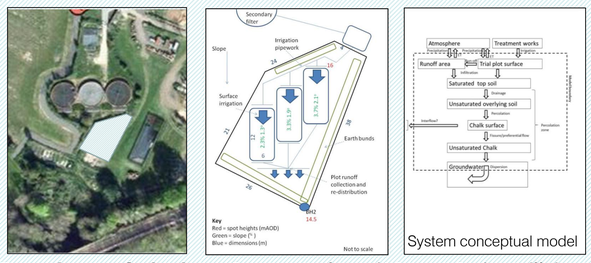
b). Increased MT (circles indicate areas exposed to increased saturation duration)



c). Increased MT (circles indicate areas exposed to increased drought duration)

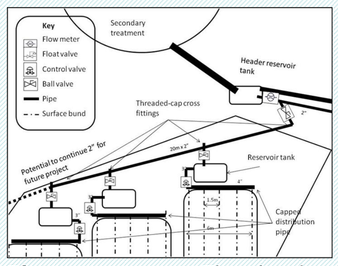
Increasing MT can increase the range of hydrological niches and subsequently species richness. Each area of the graph represents a particular hydrological niche and each point represents a particular species that may be found in that niche (adapted from Silvertown *et al.* 1999).

Field trial to test hypotheses

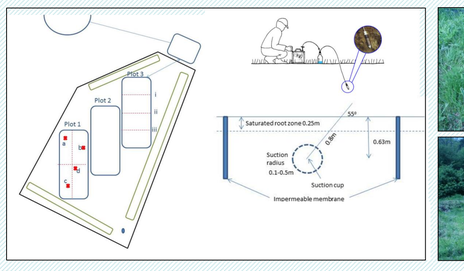


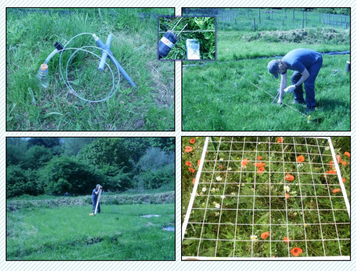
System conceptual model

Experimental design. 3 grass plots (12m x 3m) will be used to compare; flat surface (control) against ridged (treatment). A 2-phase 'intervention analysis' approach employed to overcome lack of replication. 1st phase all plots as control. 2nd phase 1 control plot and 2 treatment plots.



Plot management. The plots have been seeded with an MG8 wet grassland mix and are being surface irrigated from the top of the slope. The irrigant is secondary treated effluent from the adjacent works. The annual loading is set to an irrigation depth of 4.7m.





Data collection. The data collection includes; MT transect surveys, soil moisture surveys, subsurface soil water N & P concentrations, vegetation surveys, soil & vegetation nutrient concentrations, soil redox potential surveys, denitrifying enzyme activity, soil organic matter, soil phosphorus sorption index and sodium adsorption ratio.

Proposed modelling using HYDRUS with wetland module

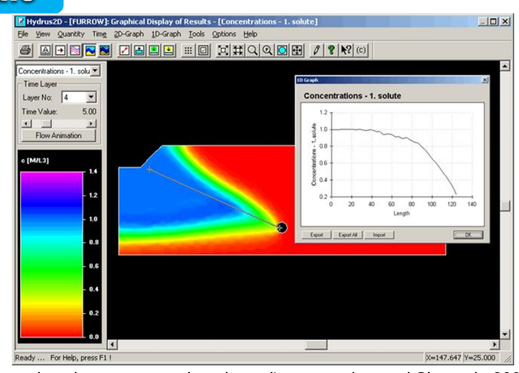
Aim to enable the findings of this research to extrapolated to a wider range of systems

Objective 1 using HYDRUS model the hydraulic and biogeochemical processes of a soil-based treatment system based upon parameter values obtained from the field trial.

Objective 2 evaluate the use of HYDRUS for this application; validate using modelled and observed data for the field trial.

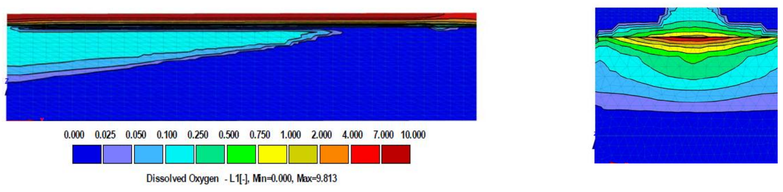
Objective 3 within the modelled field trial, optimise microtopography and irrigation loading to establish a configuration that would provide optimal water treatment.

Objective 4 model combinations of varying parameters including; soil texture, microtopography, irrigation loading and climate. Use the results to create a design matrix that may aide optimal design of future soil-based treatment systems.



Example solute concentration plume (Langergraber and Simunek, 2006)

Objective 5 take various modelled outputs including cross-sectional profiles of: microbial communities; soil water content; and soil water dissolved oxygen distribution (see below for examples) and propose mechanisms for the influence of microtopography upon soil-based treatment systems.



a. Example dissolved oxygen distribution. b. Example distribution of heterotrophic organisms (Langergraber and Simunek, 2006)

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Cranfield University, Cranfield, Bedford. MK43 0AL
s.r.tyrrell@cranfield.ac.uk