Vetiver Wastewater Treatment / Disposal, & Carbon Sequestration

Chemical Engineering Research

Award Winning Research (Australian Water Association)

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Fig. 1: Root biomass

Fig. 2: Lysimeter transport

Fig. 3: LWFT near Bunbury

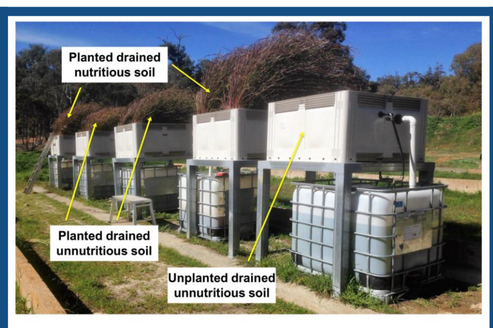


Fig. 4: LWTF wastewater

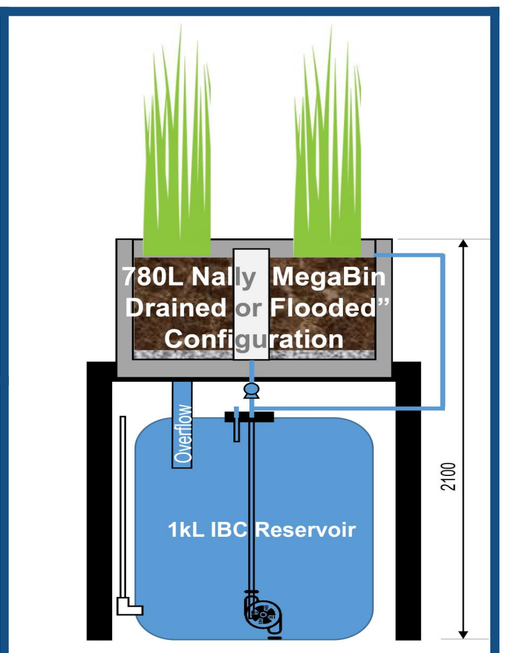


Fig. 5: Rig design

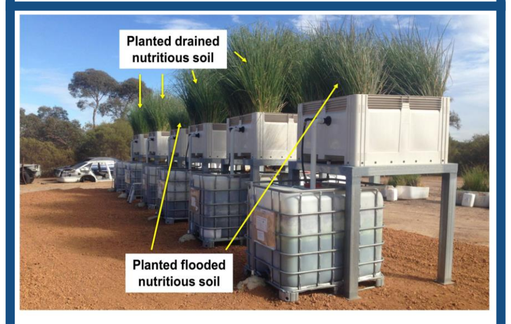


Fig. 6: Red Hill landfill

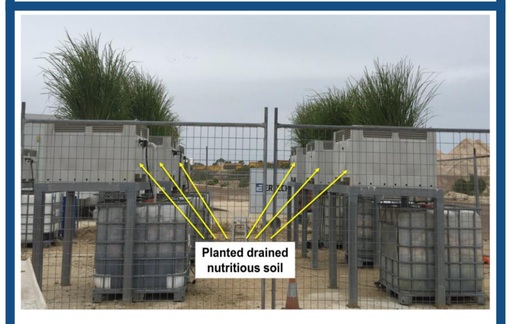


Fig. 7: Tamala Park landfill

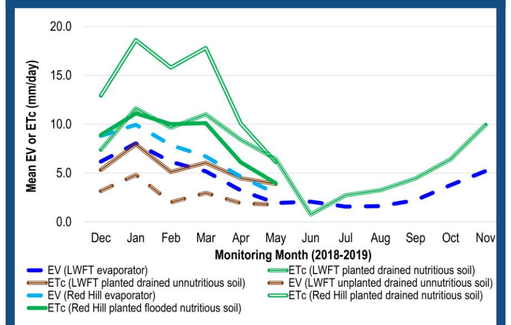


Fig. 8: Various ET rates

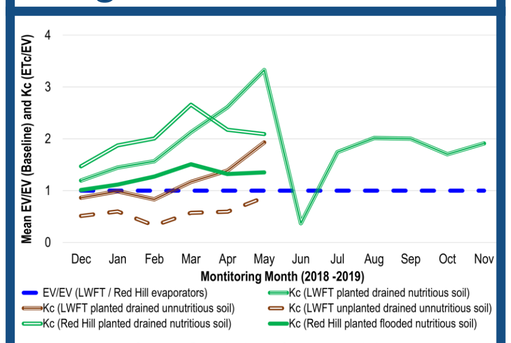


Fig. 9: Various Kc

Fig. 11: Leachate irrigation

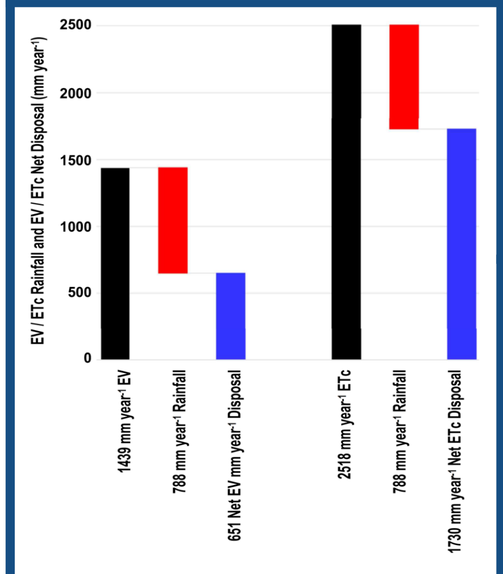


Fig. 13: Net ET disposal

Background: The Vetiver System (VS) is dependent on Vetiver Grass with reported high evapotranspiration (ET) rates & biomass production (Fig. 1).

Objectives: Obtain data on VS performance & operating parameters including:

- ET performance (wastewater / leachate disposal, & sludge dewatering);
- Carbon (C), nitrogen (N) & phosphorous (P) assimilation performance;
- Impact on performance from water/nutrition availability, climate & salinity.
- Other N, P & pathogen treatment processes in the ebb & flow VS.

Method: Rain gauges, Lysimeters & evaporators (Figs. 2-7), were used to find relative ET & net disposal rates (8 – 11, 13). Pre / post treatment wastewater analysis, dry yields, & tissue analysis were used to find assimilation rates, & contribution of soil processes to treatment (Fig. 12, 14 - 15, 17). Current carbon prices were used to evaluate potential CO_2e sequestration income (Fig. 16).

Results & Discussion: Results are given in Figures 8 – 17. Key findings include:

- Highest ET performance achieved in drained nutritious soil (Figs. 8 – 9) indicating beneficial net annual disposal rates (Fig. 13).
- Saline landfill leachate irrigation resulted in rapid VS failure (Figs. 10 - 11).
- High P, N & C assimilation rates (Fig. 12, 14 - 15 & 17) & further soil treatment of N & P (Figs. 14 - 15) was achieved. Soil treatment reliably reduced E. coli to ≤10 cfu/100ml.
- High biomass production (Fig. 12) indicates good potential for carbon sequestration farming (Fig. 16 - 17).
- The solar edge effect in these studies is likely to have amplified performance.

Conclusions: Studies indicate VS is suitable for wastewater disposal, biosolids dewatering, and N, P & pathogen treatment. VS is unsuitable for treatment or disposal of typical Perth landfill leachates. Exceptionally high root biomass production indicates VS could also make a significant contribution to carbon sequestration. This could generate significant carbon farming income in Australia should a carbon pricing mechanism be introduced. These preliminary studies have demonstrated the research value of upsize field studies.

Further Research: Proposals for currently estimated $1.8m upsize field studies are currently being prepared. These will control for edge effect, & incorporate lessons learned for improved repeatability & significance of statistical analysis. Further research will also contribute to establishment of reliable methods of VS carbon accounting. This is necessary for a regulatory framework to incentivise VS carbon farming in an accelerated timeframe. Expressions of interest in these studies should be directed to the team below.

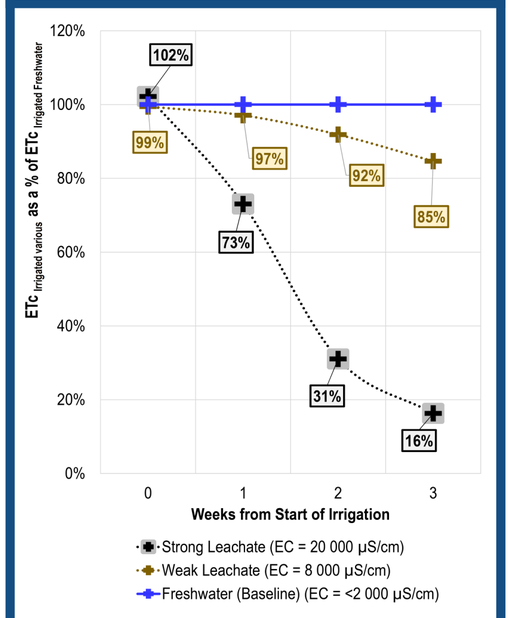


Fig. 10: Leachate ET rates

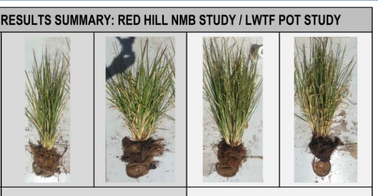
DRY YIELD RESULTS SUMMARY: RED HILL NMB STUDY / LWTF POT STUDY					
LWTF Pot Study Harvested Vetiver (Prior to oven drying)					
Soil Type (Drained)	**Nutritious Soil (Standard Soil 1)**		**LWFT Biosolids Soil 7**		
Dry Shoot Yield (DSY)	**66 t ha^{-1} year^{-1}** (Red Hill NMB Study)		**101 t ha^{-1} year^{-1}** **154% Soil 1** (LWFT Pot Study)		
Dry Root Yield (DRY)	**44 t ha^{-1} year^{-1}** **66.6% DSY** (LWFT Pot Study)		**67 t ha^{-1} year^{-1}** **154% Soil 1** (LWFT Pot Study)		
Total Dry Yield (TDY)	**110 t ha^{-1} year^{-1}** DSY + DRY		**169 t ha^{-1} year^{-1}** **154% Soil 1** (LWFT Pot Study)		

Fig. 12: Dry yield studies

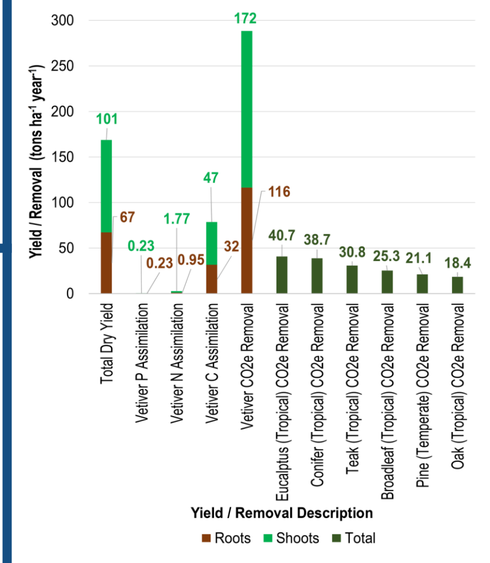


Fig 17: Assimilation

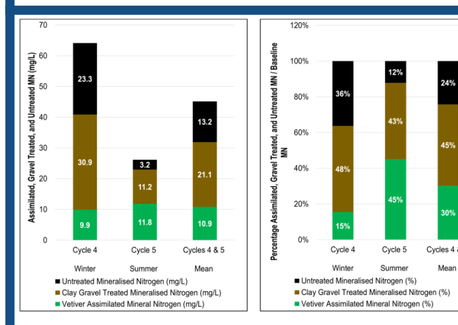


Fig. 14: N treatment

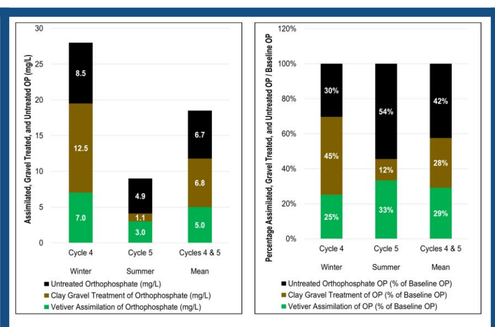


Fig. 15: P treatment

Country	Australia	New Zealand	France	Finland	Liechtenstein	Switzerland
Pricing Mechanism (The World Bank, 2021)	None Reported[1]	Emissions Trading Scheme	Carbon Tax	Carbon Tax	Carbon Tax	Emissions Trading Scheme
Nominal Carbon Price: USD per tCO^{2}e (The World Bank, 2021)	$14	$26	$52	$73	$101	$137
Nominal Carbon Price: AUD per tCO^{2}e 1USD = 1.4AUD (xe.com, 2021)	$20	$36	$73	$102	$142	$192
Potential Carbon Farming Income AUD: Dry Root Yield (DRY) 116 t ha-1 year-1	$2,320	$4,183	$8,508	$11,828	$16,479	$22,291
Potential Carbon Farming Income AUD: Dry Shoot Yield (DSY) 172 t ha-1 year-1	$3,440	$6,203	$12,616	$17,537	$24,434	$33,052
Potential Carbon Farming Income AUD: Total Dry Yield (TDY) 288 t ha-1 year-1	$5,760	$10,386	$21,124	$29,365	$40,913	$55,343
Boundcore Farming: Income ha-1 year -1 (Gill, 2019)	$711	No Data				
Boundcore Farming: Profit ha-1 year-1 (Gill, 2019)	$334					

[1] Foley, 2021 report that the Australian Federal Government have failed to legislate for a carbon pricing mechanism. The AUD$20 is based on a recent corporate carbon spot price reported by Foley. This means that until there is a change in Australian Federal Government Policy the potential opportunities for Australian farmers are much more limited than in other jurisdictions, with massive lost opportunities both for Australian farmers and the environment.

Fig. 16: C sequestration

Funding Bodies: Australian Government Research Training Program Scholarship, City of Armadale, City of Busselton, Cleanaway Pty Ltd, Cockburn City Council, Eastern Metropolitan Regional Council, Lennard Waste PTY LTD, Mindarie Regional Council, Suez Recycling & Recovery Pty Ltd

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