MODELLING LANDFILL STABILISATION:

HYDRAULIC-BIODEGRADATION PROCESSES

John McDougall & Ian Pyrah

School of the Built Environment
Napier University, Edinburgh, UK
j.mcdougall@napier.ac.uk

Mark's Questions

Current capabilities and constraints ...

Waste composition? - phase/material/elemental

Physical character? - infilling stage

Microbiological detail? - 2/3/4SAAD

Verification & validation? - Comprehensive field tests

Coupling? - Key to improved modelling

Coupling - scale issues - appropriate field data

Moisture

- key biodegradation factor

Biodegradation

- major settlement component

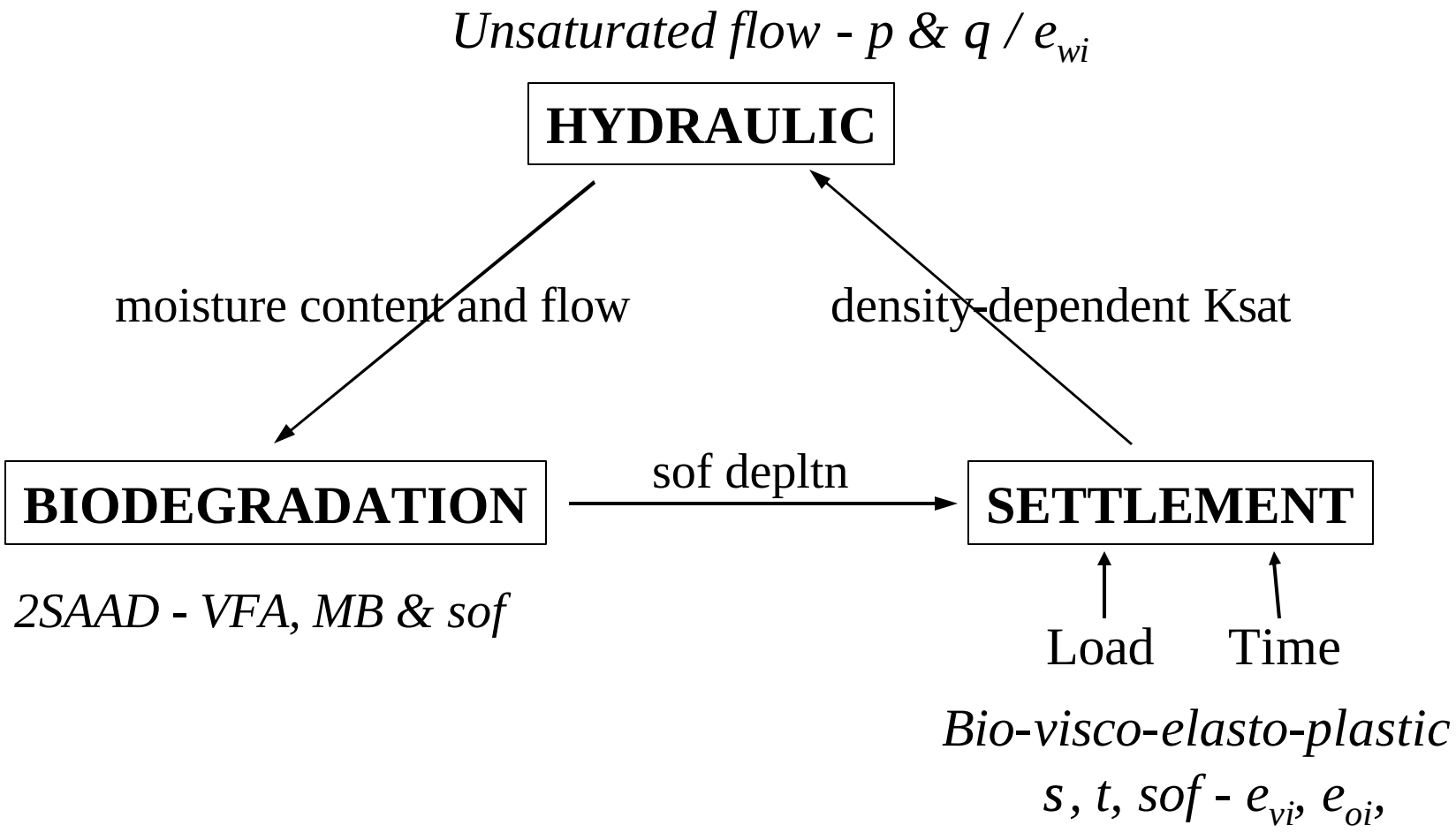
Density (dry)

- vary by 2x .. 3x

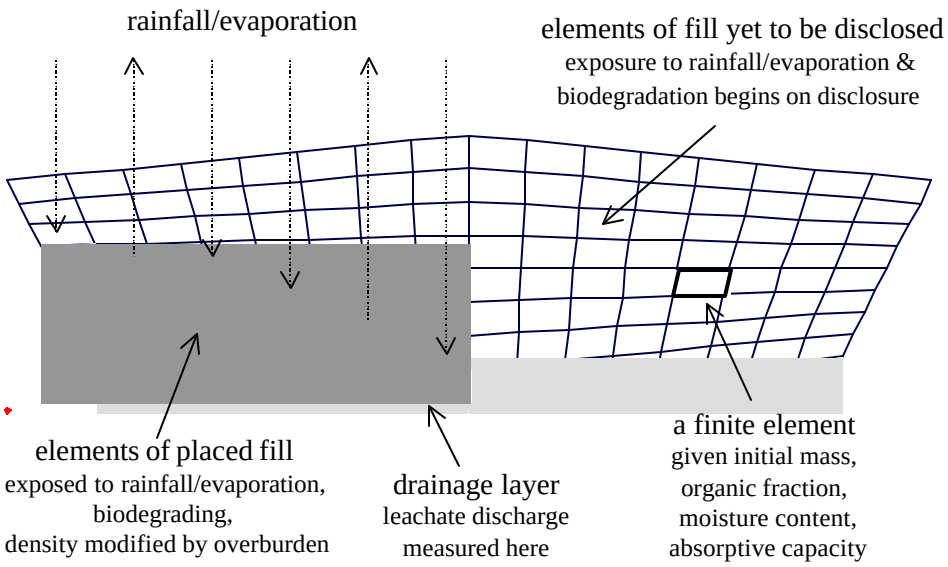
Hydraulic conductivity (sat'd)

- vary by 100x ..10000x

A more fundamental approach to landfill modelling



Implementation - finite element method



DATAPREP - Control Data for HyBi1.f95

Edit Data Files Help About Dataprep Exit

Run ID: 7000

Title: Waste column with infiltration

Time: Transient — Increment (days): 0.2 — Duration (days): 500

Material Properties

Number of Sets: 1 — Set 1 — Set 2

	Set 1	Set 2
Soil Type:	Waste	
Hydraulic Properties		
Water Retention(van Genuchten)		
alpha	0.6	0
n	1.46	0
Residual M.C.	0.14	0
Saturated M.C.	0.375	0
Saturated Conductivity		
Horizontal (m/day)	4.32	0
Vertical (m/day)	4.32	0
Specific Storage	0	0
Porosity	0.375	0
Biodegradation Properties		
Hydrolysis Rate (mg/L/day)	2500	0
Initial Organic Content (kg/m3)	310	0
Methanogen Growth (1/day)	0.02	0
Methanogen Death (1/day)	2.00E-03	0
Diffusion Coefficient (m2/day)	0.05	0

Boundary Conditions

Hydraulic Sets: 1

Neumann — Number of nodes: 2 — Prescribed Value: -50

Node Numbers (10 max): 21 22

Perm Dirichlet — Number of nodes: 0 — Prescribed Value: 0

Node Numbers (10 max):

Perm Dirichlet — Number of nodes: 0 — Prescribed Value: 0

Node Numbers (10 max):

Biodegradation Sets: 0

Number of nodes: 0 — Prescribed VFA: 0 — MB: 0

Node Numbers (10 max):

Number of nodes: 0 — Prescribed VFA: 0 — MB: 0

Node Numbers (10 max):

Graphics Output Control

At time steps: 2 5 10 25 50 100 250 500 750 1000 1250 1500

Flux data recording interval (time steps): 10

Biodegradation Control

Half Rate Constant (mg/L)	4000
Product Inhibition Fact (L/mg)	2.00E-04
Digestibility Structural Transformation Parameter	0.7
Yield Coefficient	0.2

Numerical Control

Relaxation	1
Kappa	0.4
Lambda	0.4
Theta_h	1
Theta_b	1

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SEEPVEC4 - Model geometry, flux vectors & moisture profiles

Print page Next time step Exit About Seepvec4

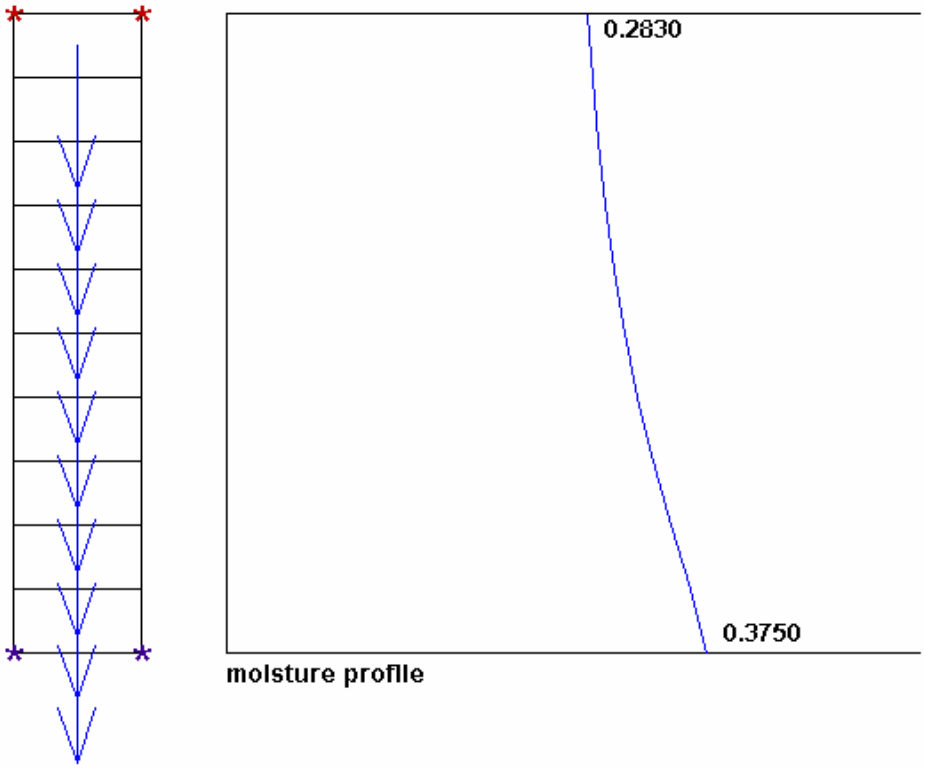
Waste column with Infiltration **Run ID =** **7000** **08/10/2002**

Time step = 1000
Time elapsed [days] = 200.0

Vector scaling
- minimum = 8.100E-03
- maximum = 8.100E-03
- scalar = 1.000E+04

K(sat)h [m/day] = 4.320E+00
K(sat)v [m/day] = 4.320E+00

Solution tolerances
- Gauss Seidel = 1.0E-07
- Matrix update = 1.0E-03
- Termination = 1.0E-04



moisture profile

LEGEND
* = Dirichlet boundary cond
* = Neumann boundary cond

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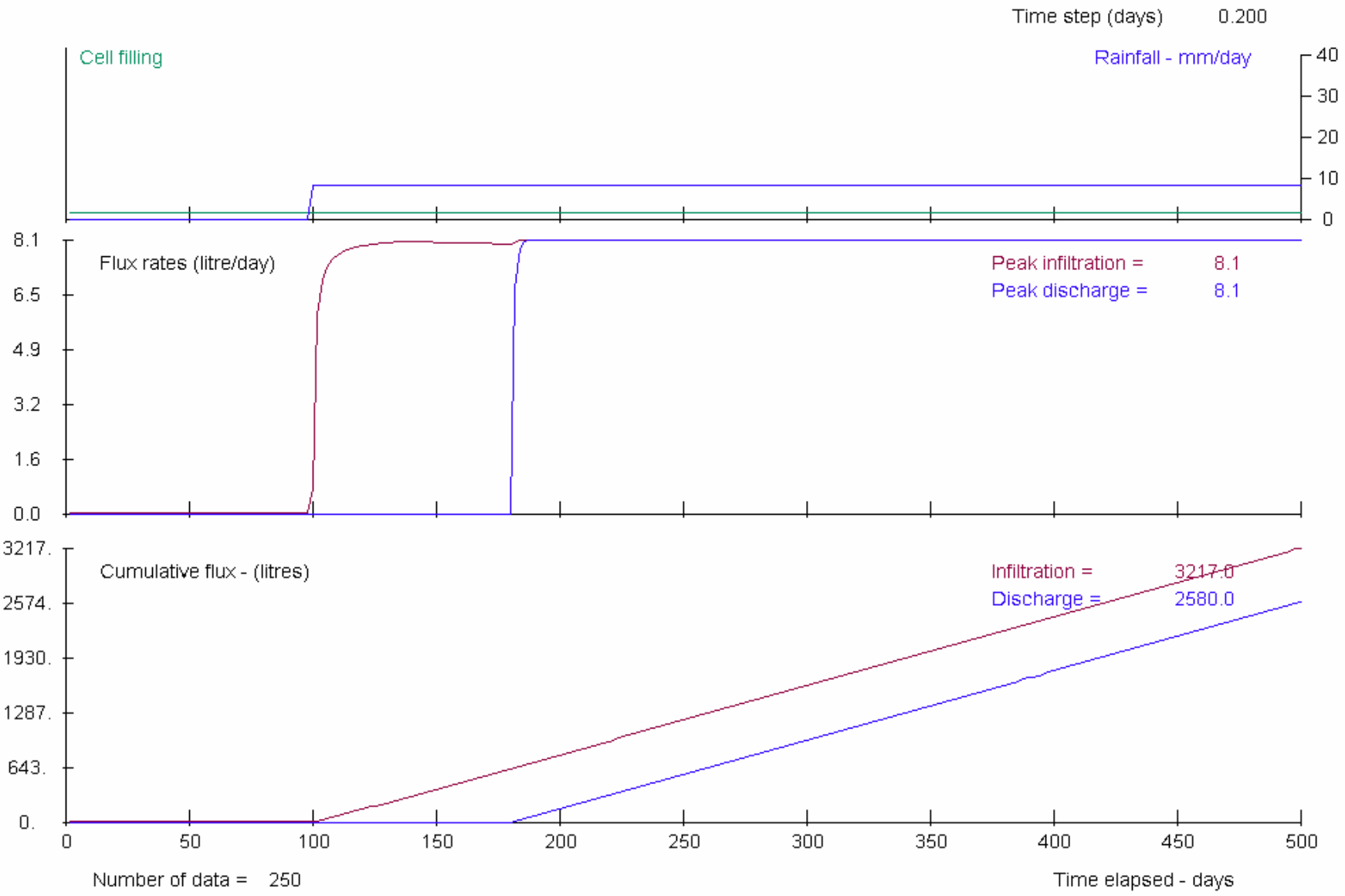
LIXFLUX - Infiltration + Discharge data

Print page Exit About Lixflux

FLUX DATA: Waste column with Infiltration **Run ID: 7000** **08/10/2002**



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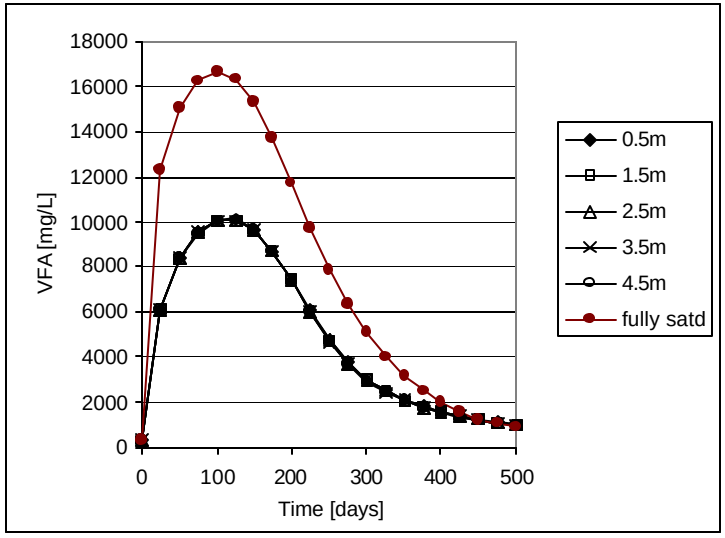
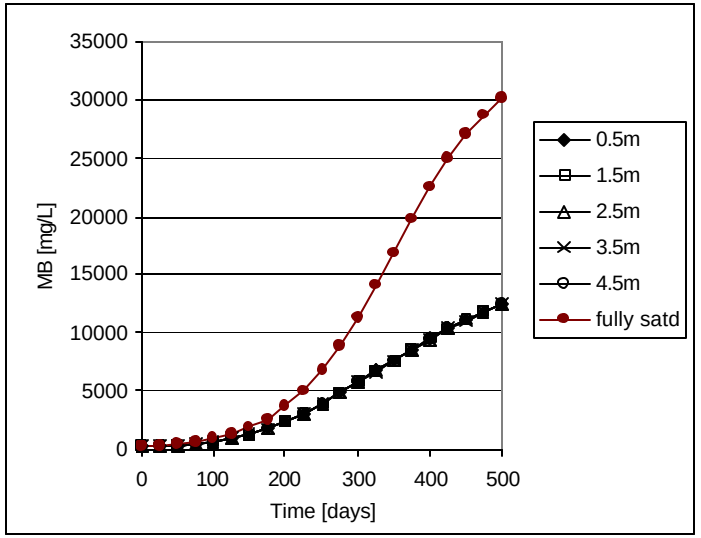
Coupling hydraulic and biodegradation processes

Waste column: fully saturated vs. unsaturated - no water addition

VFA concentration with time



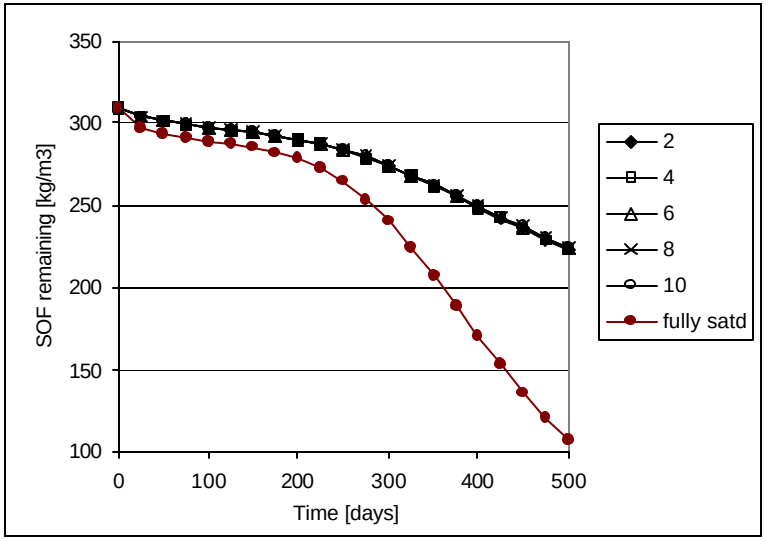
MB concentration with time



Typical evolution (at least in VFA); moisture constraint impacts directly on VFA and on MB through lower substrate production.

Coupling HB processes - saturated vs. unsaturated

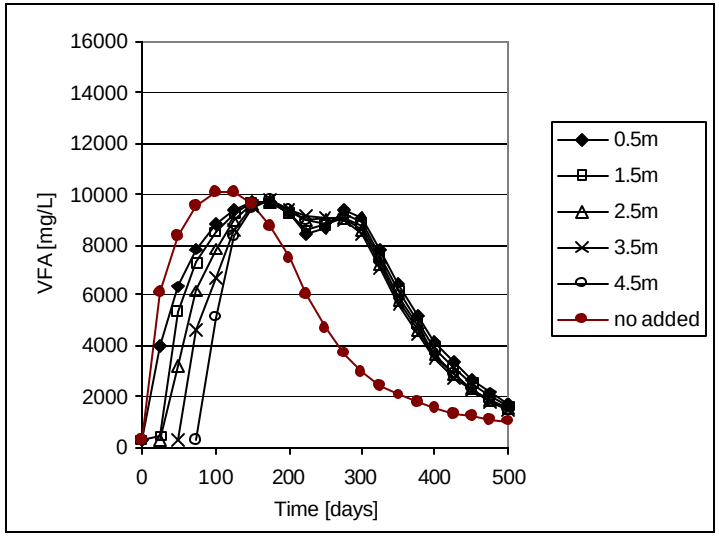
… and on sof depletion



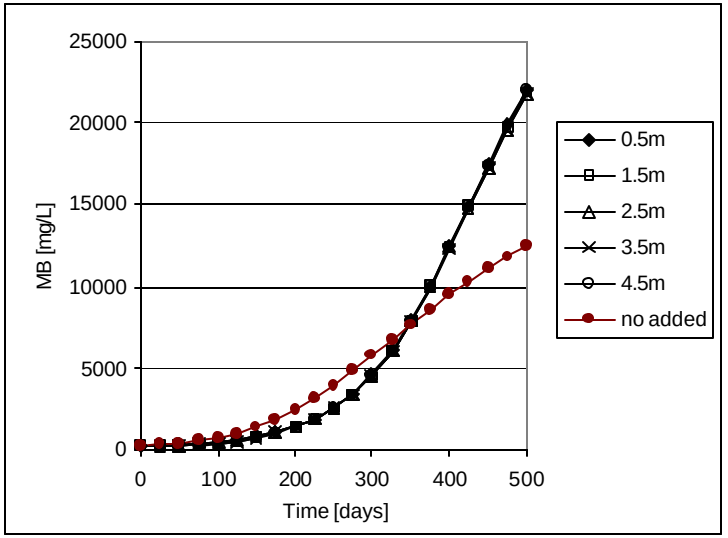
Coupling HB processes - unsaturated+infilling+recirculation

Infilling: days 0-100
Leachate addition: discharge quality - from day 201

VFA concentration with time



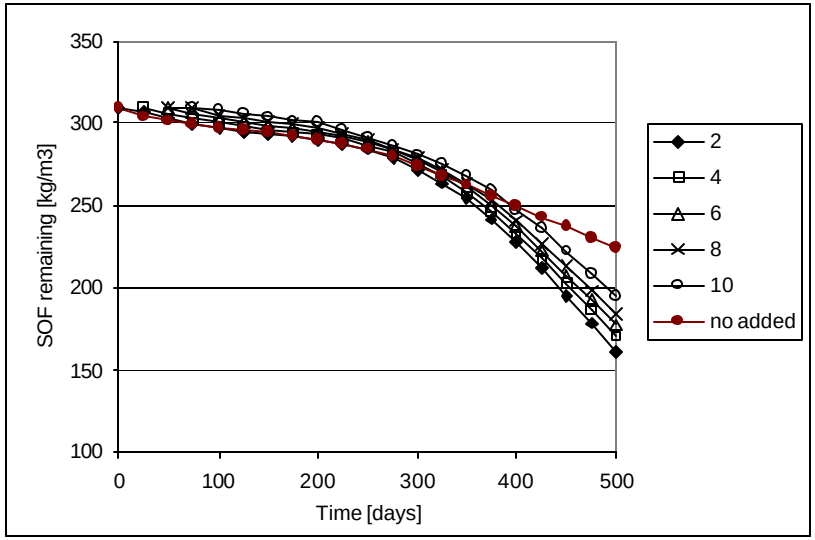
MB concentration with time



VFA accum staged - homogenised by diffusion
Recirculation - wetting of upper levels promotes VFA production blip
Complete wetting (300d) produces VFA and MB accum accelerates ...

Coupling HB processes -

… with concomitant acceleration in sof depletion at various levels

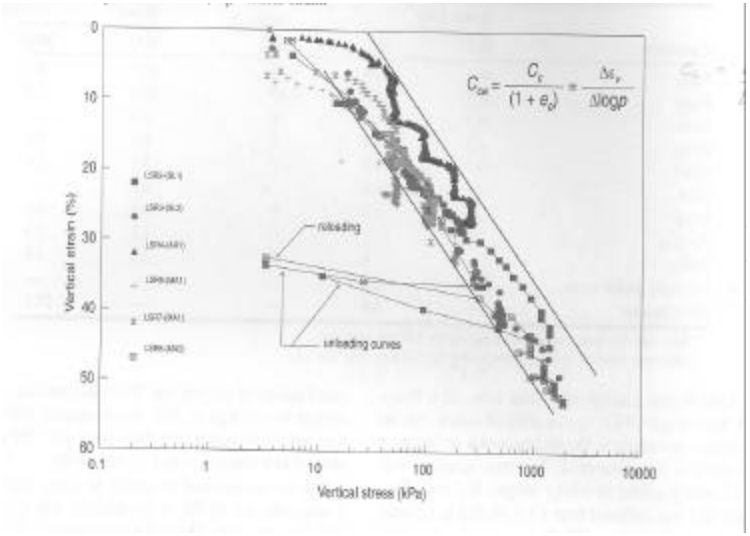


Analysis of various flux, fill sequence, & biodegradation boundary conditions, e.g. nutrient seeding

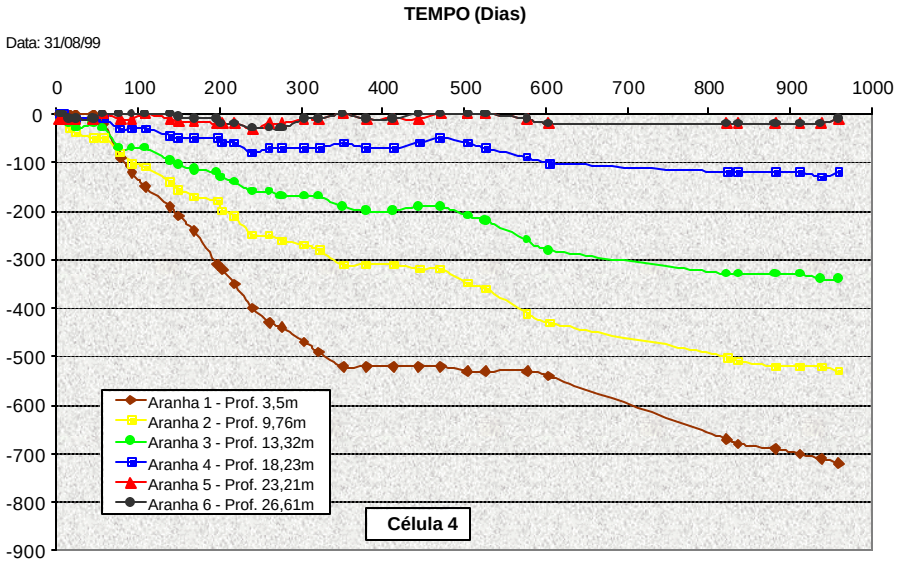
Mechanical processes? - HBM model

Settlement data:

Load/self weight Creep Biodegradation



Landva et al, 2000

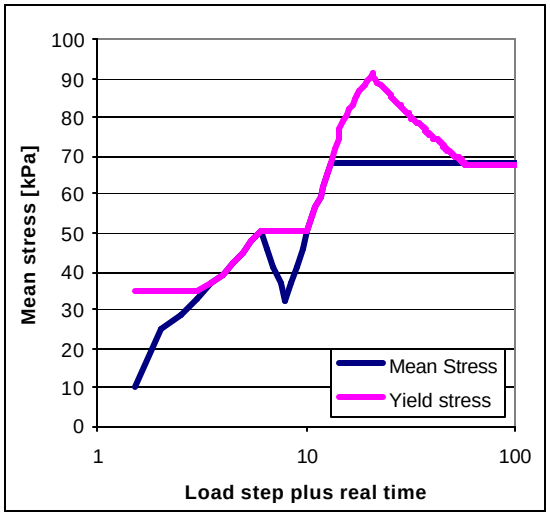


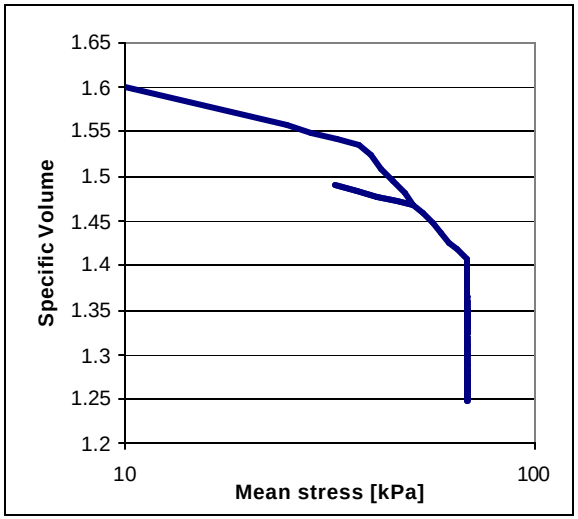
Muribeca 2002; Monteiro, pers comm

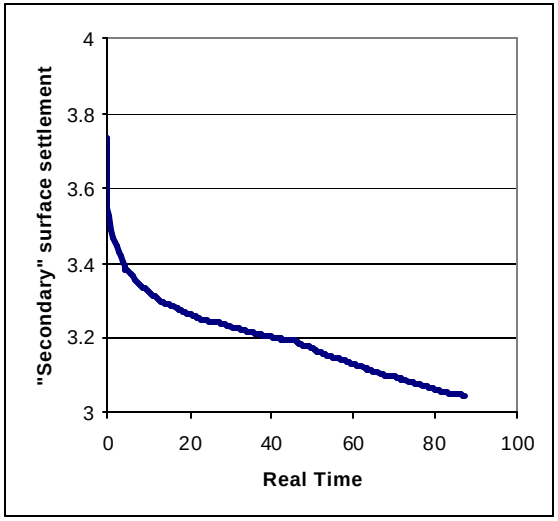
Mechanical behaviour / consequences

Bio-visco-elasto-plastic behaviour

Elasto-plastic (load) deformation
showing creep stiffening
followed by biodegradation softening and post yield deformation







Summary

What are we doing/where are we?

Coupling fundamental models of HBM behaviour.
Conceptual framework for a more holistic analysis,
including plausible depiction of infilling .

What do we need to do/where should we go?

Review phase description
Identify fundamental constitutive relationships - parameters
Refine coupling - laboratory & field scale
Validate

What can we offer now?

Key contribution to field-scale monitoring - validation