Mecoprop attenuation in landfill liner clays

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ASSESSING THE POTENTIAL FOR BIODEGRADATION AND SORPTION OF ORGANIC LIST I SUBSTANCES WITHIN LANDFILL LINERS

(Environment Agency Project SC020039/5)

- **Literature review**
- **Laboratory experiments**
- **Identify the solid phases involved in contaminant sorption**
- **Assess the potential for release of sorbed contaminants**

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Aim

- To assess the potential for retardation of Mecoprop by two landfill liner clays

Objectives

- To obtain sorption coefficients for Mecoprop by batch testing
- To determine retardation of Mecoprop relative to a conservative tracer

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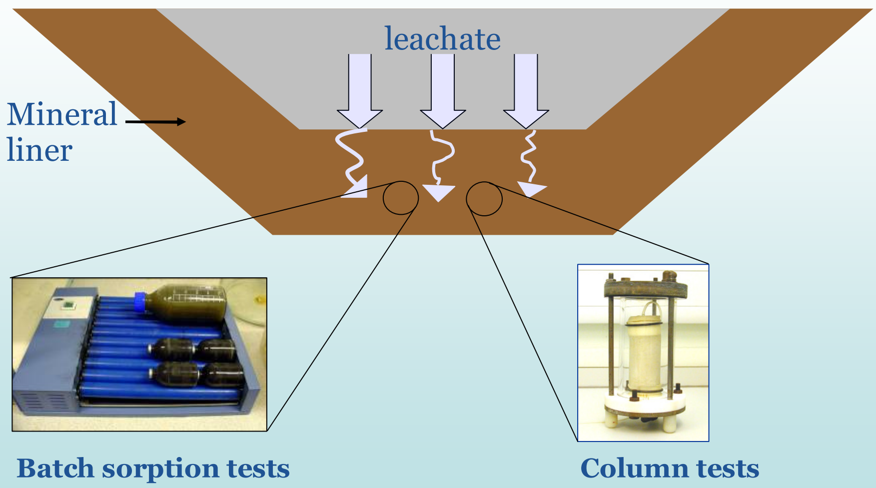

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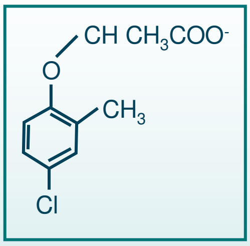
Mecoprop (MCPP)



- phenoxyalkanoic herbicide
- polar, negatively charged at pH 7-9
- Log K_{ow} (dissociated) = 0.1
- present in 98% of UK landfill leachates
  - median = 11 μg/l
  - range = 0.1 to 140 μg/l
- biodegrades under *aerobic* conditions, but little or no biodegradation in *anaerobic* conditions

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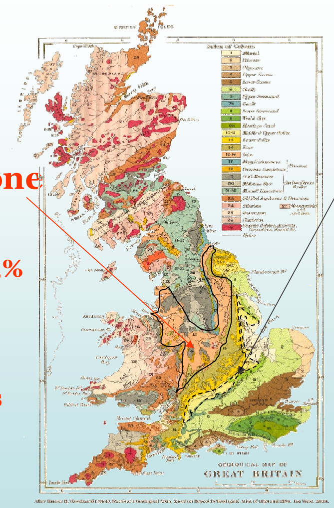
Mercia Mudstone

- **Total carbon 2%**
- **Organic carbon 0.3%**
- **Illite 36%**
- **Smectite 18%**
- **Evaporite minerals (halite, gypsum and anhydrite)**
- **Iron oxides 6.3%**
- **Surface area 36 m^2/g**



Oxford Clay

- **Total carbon 7.2%**
- **Organic carbon 5.5%**
- **Illite 15% Smectite 32%**
- **Kaolinite 9%**
- **Calcite 9%**
- **Iron oxides 4.5%**
- **Surface area 53 m^2/g**

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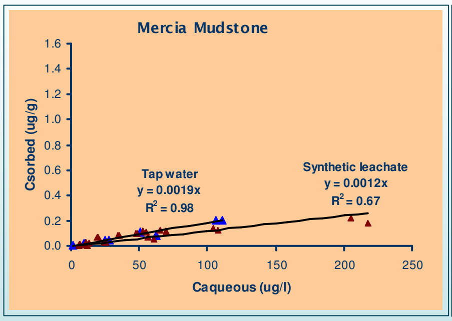

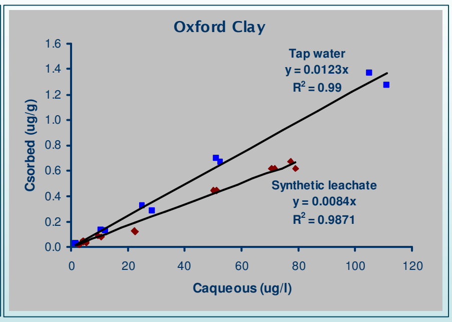

Batch sorption tests

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	Linear Model $C_{sorbed} = K_d C_{aq}$		Freundlich Model $C_{sorbed} = K_F C_{aq}^n$		
	K_d (x 10^3) (l/g)	R^2	K_F (x 10^3) ($\mu g^{1-n} l^n/g$)	n	R^2
Mercia Mudstone					
Tap water	1.9	0.98	2.7	0.92	0.99
Synthetic leachate	1.2	0.67	2.8	0.87	0.85
Oxford Clay					
Tap water	12.3	0.99	12.3	0.99	0.99
Synthetic leachate	8.4	0.94	9.2	0.99	0.96
Literature values					
Soils*	0 to 2.8				
Aquifer sediments*	0 to 0.26 (sand)				

*Environment Agency, 2004

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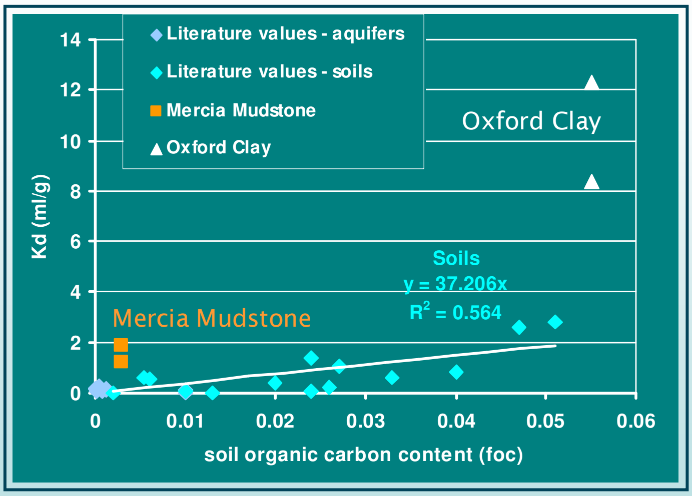

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	Linear Model $C_{sorbed} = K_d C_{aq}$		Freundlich Model $C_{sorbed} = K_F C_{aq}^n$		
	K_d (x 10^3) (l/g)	R^2	K_F (x 10^3) ($\mu g^{1-n} l^n/g$)	n	R^2
Mercia Mudstone					
Leachate (sorption)	1.2	0.67	2.8	0.87	0.85
Leachate (desorption)	1.4	0.95	2.5	0.88	0.95
Oxford Clay					
Leachate (sorption)	8.4	0.94	9.2	0.99	0.96
Leachate (desorption)	8.6	0.88	7.6	1.00	0.89

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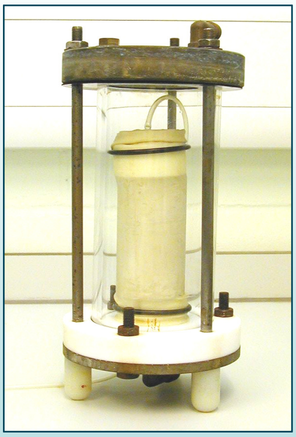
Column tests



- Clay – ground to <63μm
- Mixed with de-aired water and consolidated
- Standard triaxial cell, but the sample wrapped in PTFE to prevent sorption of Mecoprop to cell components
- Cell pressure 160kPa, base pressure 140 kPa, top pressure 0kPa - effective stress 90kPa

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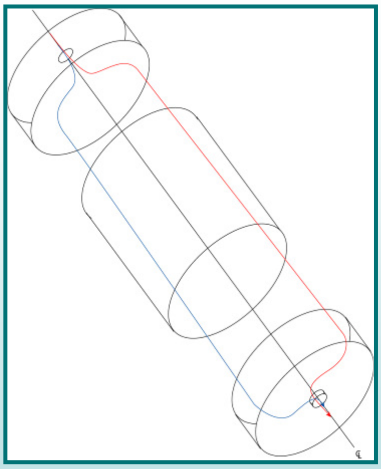

- **10 transport tests in triaxial cell**
- **Tap water and synthetic leachate**
- **'Top-hat' input of Bromide (Br) and Mecoprop (MCPP)**
- **6 samples (Mercia Mudstone – MM & Oxford Clay - OC)**

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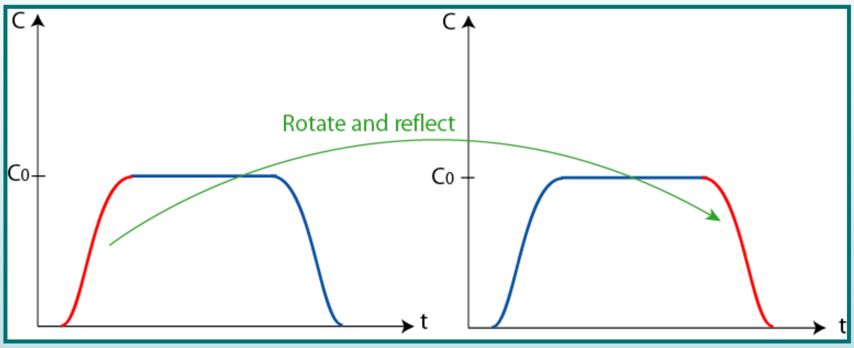
Simple analyses:

'linearity test', moments (mass-balance, mean times)



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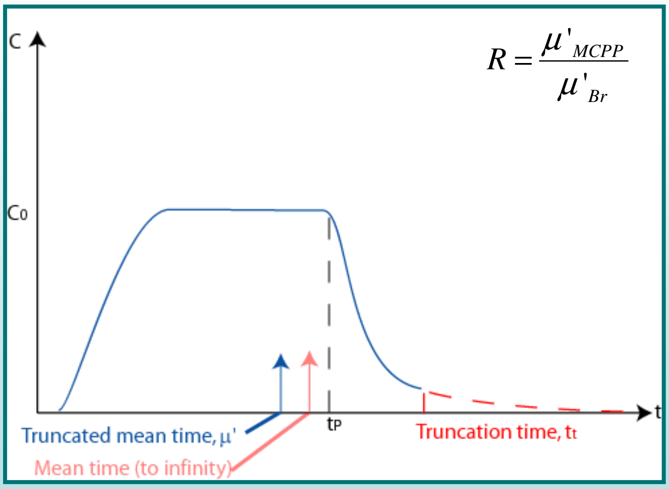
R from (truncated) moments



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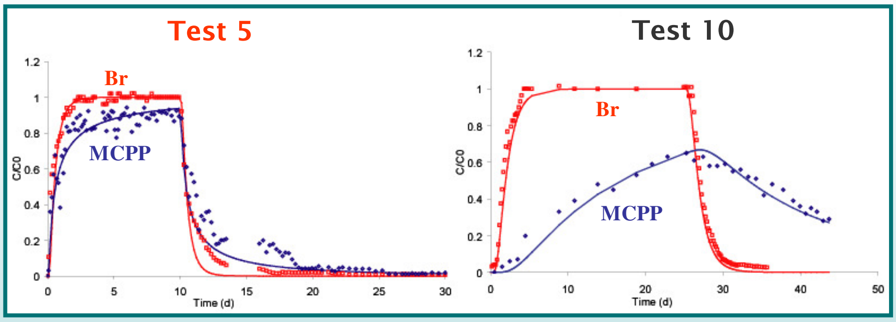
Some breakthrough curves



	Mercia Mudstone	Oxford Clay
R	4.3	12.5
Pe	3.1	5.6
t_A (days)	0.65	2.3
K (m/s)	1.2×10^{-9}	5.9×10^{-10}

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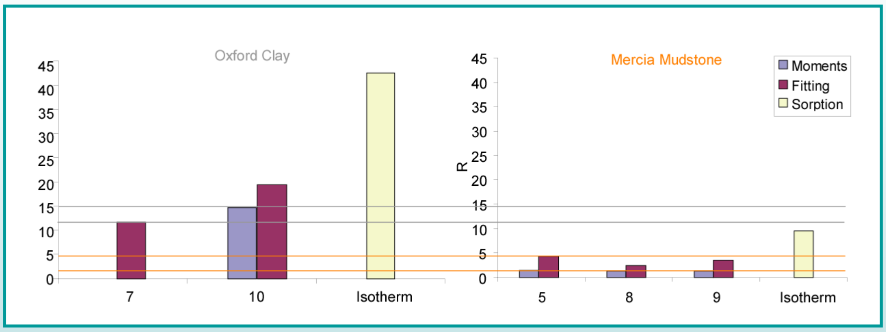
Retardation, *R*



Retardation determined from sorption batch tests according to:

$$R = 1 + \frac{K_d \rho_B}{\theta}$$

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Further analysis

- Transverse diffusion important
- Noise: non-gaussian and autocorrelated
- No detectable change due to synthetic leachate
- Between sample variance in Pe

Alternative simple models

- Dual porosity: near-identical fit
- Dual porosity with AD: non-unique
- Two stream-tubes: many parameters (2N+1)

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Conclusions

- Approximately linear sorption (use retardation, R)
- No irreversible sorption
- Using batch-test isotherms over-predicts R

- **Oxford Clay** (column-tests), $R \approx 12$-15
- **Oxford Clay** (batch-tests), $R \approx 44$

- **Mercia Mudstone** (column-tests), $R \approx 2$-4
- **Mercia Mudstone** (batch-tests), $R \approx 10$

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