The Australian Wine Research Institute

Bentonites aren't bentonites

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Resources →  →

Understanding bentonite performance

1. Investigate factors affecting bentonite performance

2. Characterise bentonite properties; correlate with adsorption and settling behaviour

3. Develop alternative processing and treatment strategies

    a) Thermal modification of bentonite
    b) Inline dosing of bentonite

What Factors Affect Performance ???


Pfizer
VGR 100
VGR 100
Pfizer
Pfizer

Factors affecting ADSORPTION performance

- The effect of 6 different factors on adsorption of a purified grape protein (VVTL1) onto bentonite was investigated
- A two level ¼ fractional *factorial experimental design*
- Bentonite slurry age was also investigated

Experimental Design

Table 1

Factor	Description	Low Level	High Level
A	pH	3.0	3.4
B	Temperature	5.2^{o}C	23.6^{o}C
C	% Ethanol	10 %	13 %
D	[K]	400 mg/L	900 mg/L
E	[“phenolics”]*	100 mg/L	200 mg/L
F	[“sugar”]**	1.0 g/L	8.0 g/L

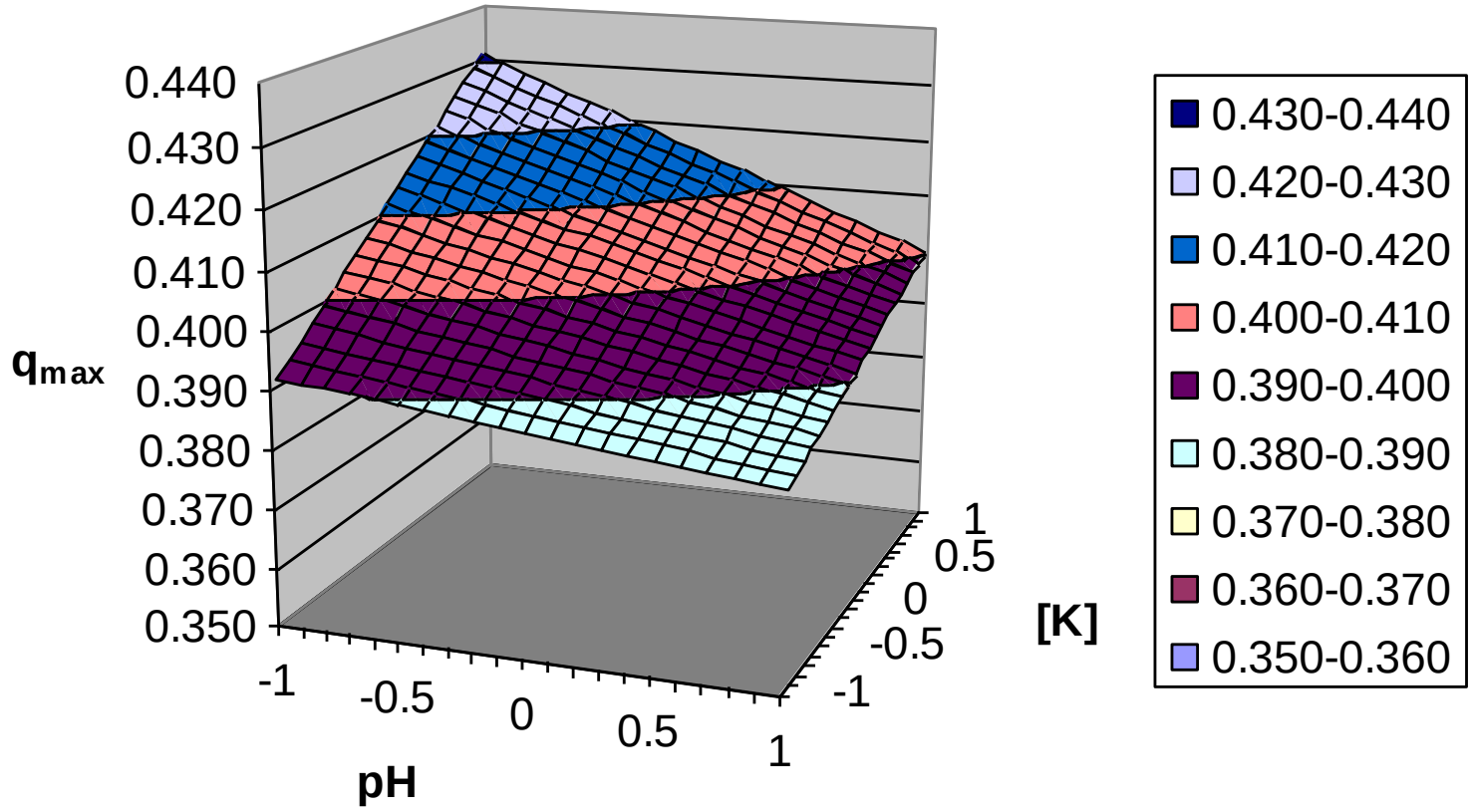
*15% w/v catachin, 85% w/v caffeic acid
**25% w/v glucose, 75% w/v fructose

Regression Model

Coefficient	i	Value	se(b_{iq})	p-value	Significance
constant	0	0.385	0.0050	0.0000	**
pH	1	-0.010	0.0025	0.0001	**
Temperature	2	0.016	0.0025	0.0000	**
% Ethanol	3	-0.001	0.0025	0.6111	ns
[K]	4	0.011	0.0025	0.0000	**
[Phenolics]	5	-0.001	0.0024	0.6042	ns
[Sugar]	6	-0.001	0.0025	0.7060	ns
Slurry age	7	3.487×10^{-04}	0.0000	0.0000	**

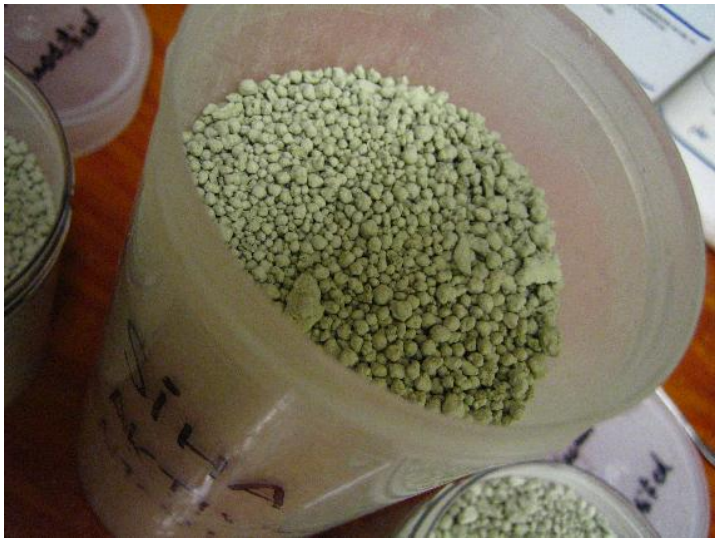
$R^2 = 0.828$ overall p-value = 7×10^{-18}

Adsorption Capacity Response Surface

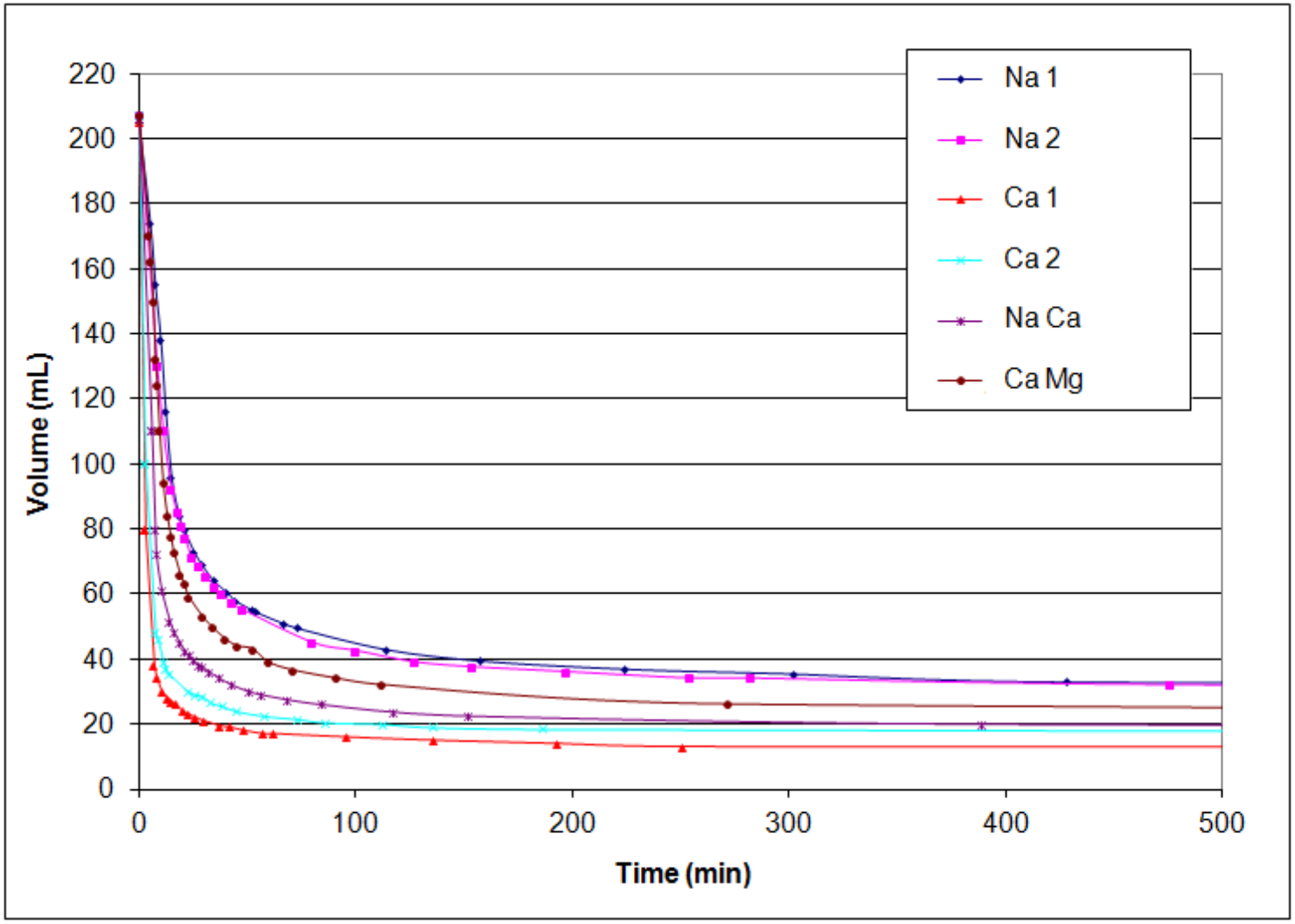


Characterisation of Physical and Chemical Properties of Bentonite

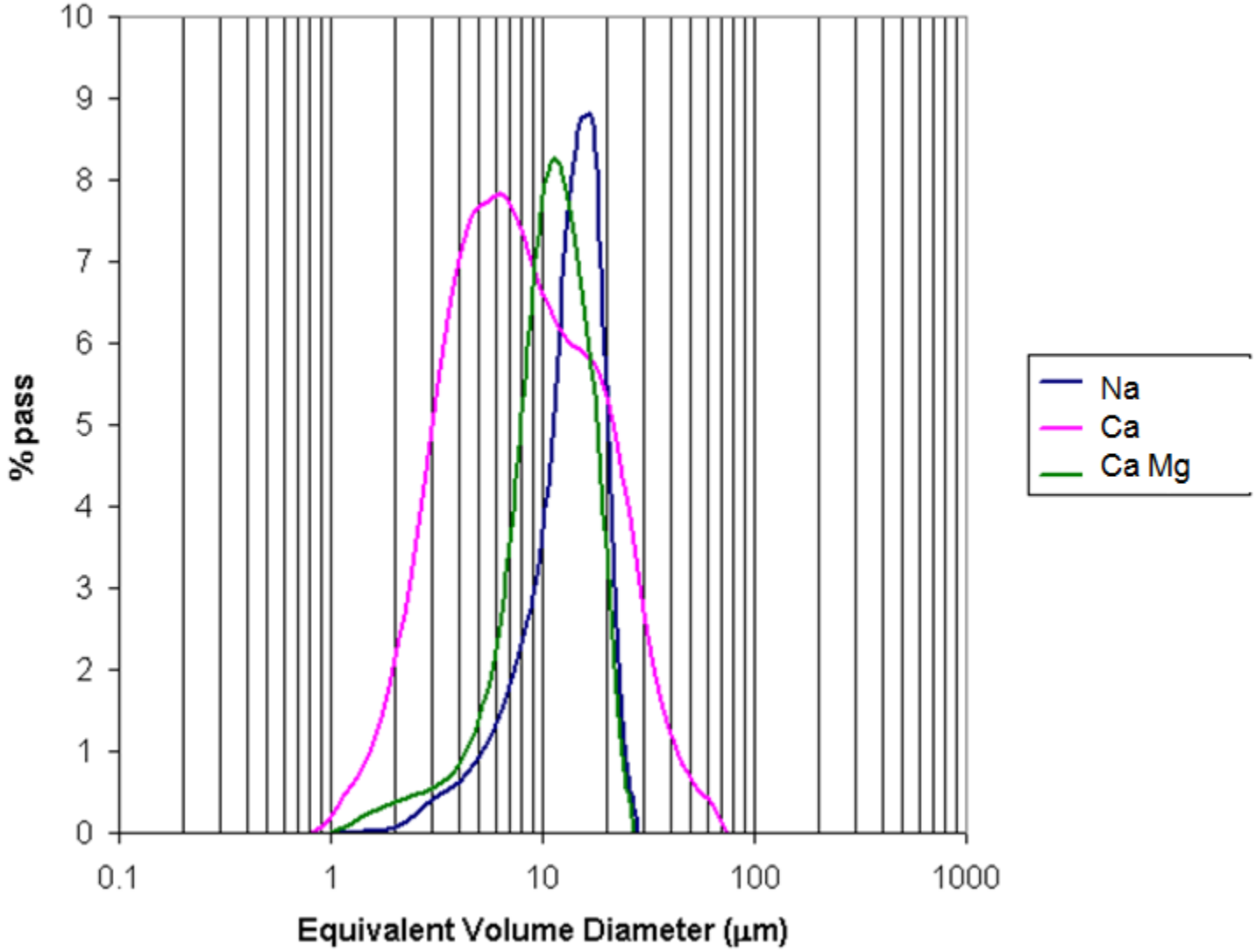
- Protein Adsorption Characteristics
- Settling Characteristics
- Particle Size Distribution
- Exchangeable Cations
- Exchange Capacity
- Particle Surface Area
- Clay Slurry Viscosity
- Zeta Potential
- Lattice spacing
- Density



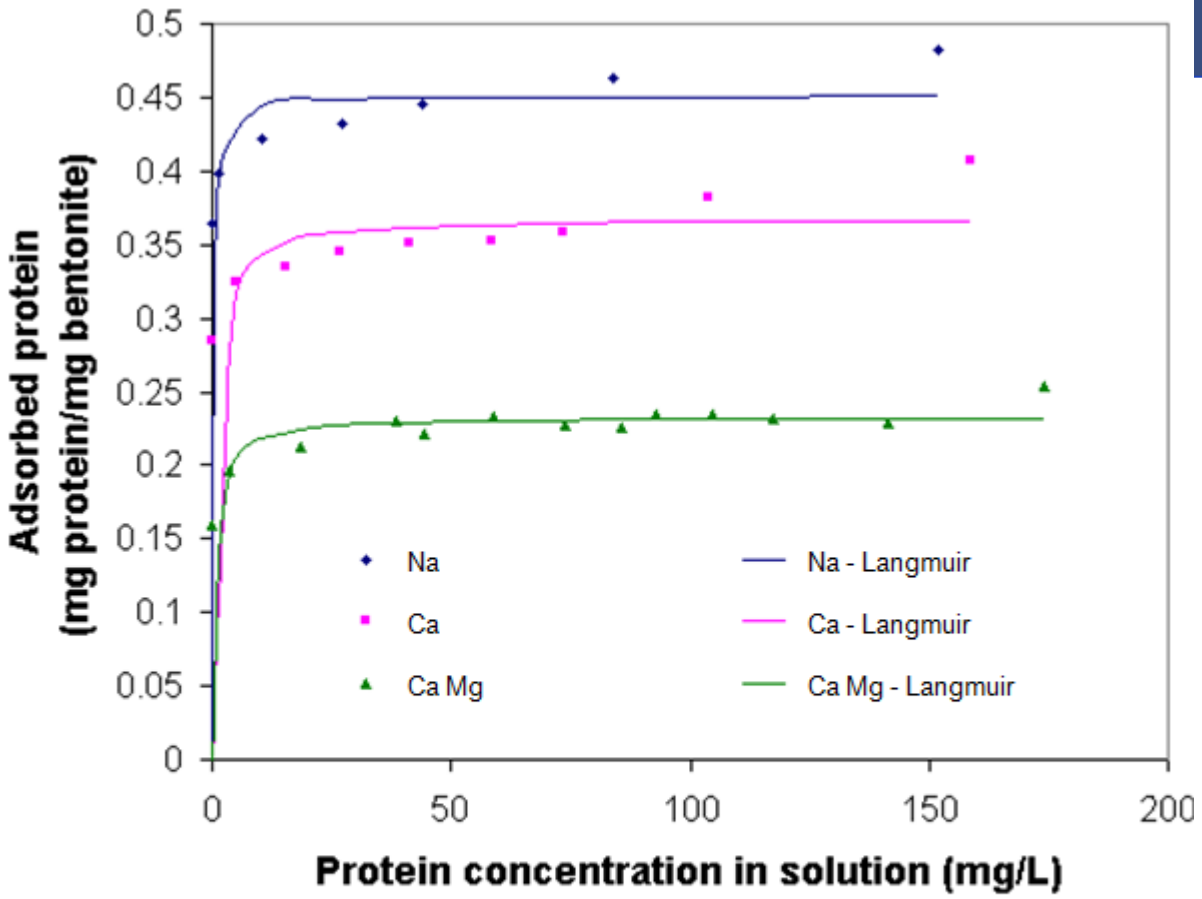
Bentonite Settling Curves



Particle Size Distribution



Protein Adsorption

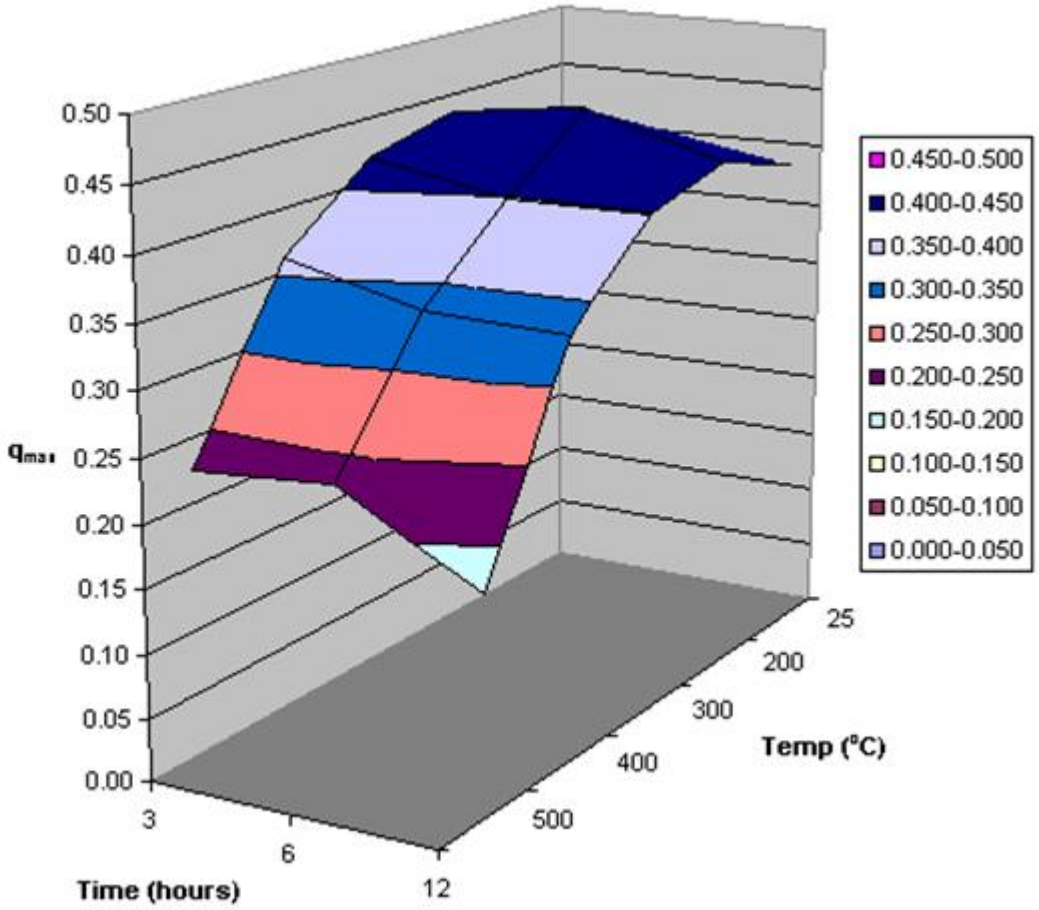


$$q = q_{\max} \frac{K_L c_e}{1 + K_L c_e}$$

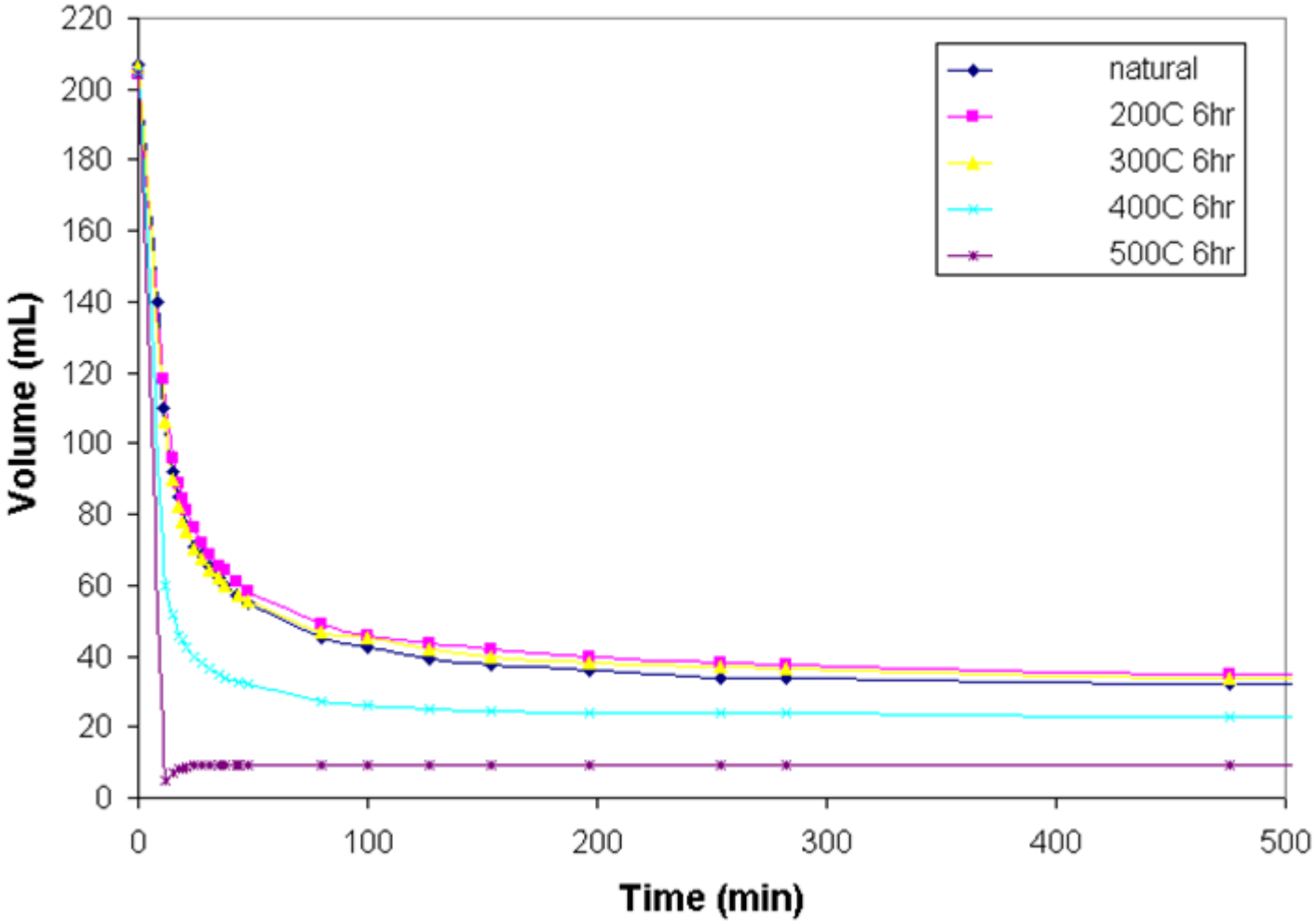
Thermal Modification of Bentonite

- Structure determines the Performance
- Heat treatment will alter bentonite structure and physical and chemical properties.
- This will affect bentonite settling behaviour and adsorption performance.

Thermal Modification of Bentonite: Adsorption Capacity



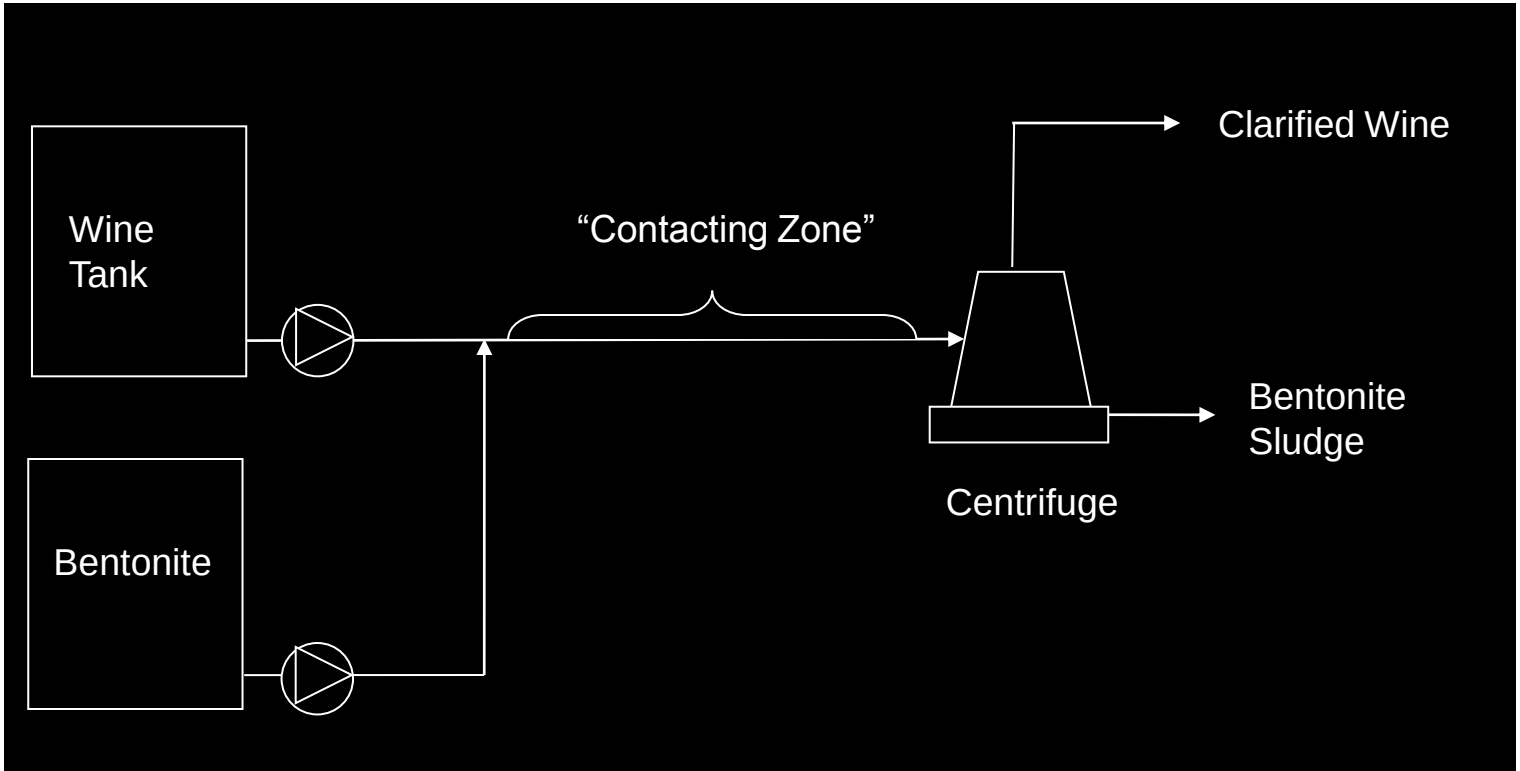
Thermal Modification of Bentonite: Settling Behaviour



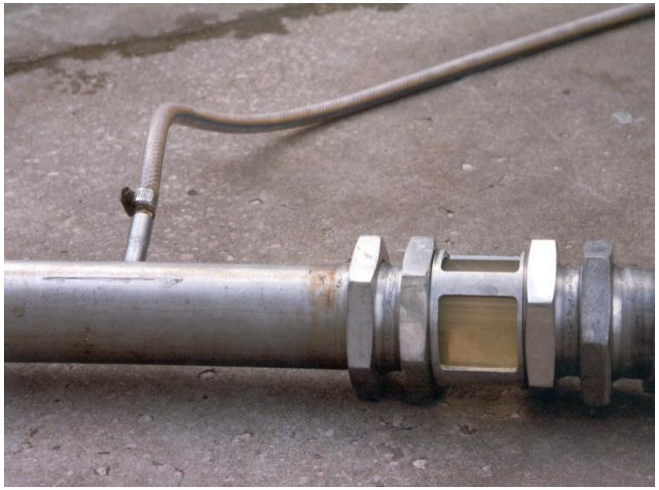
Time for a practical solution…

Inline Dosing in a commercial winery

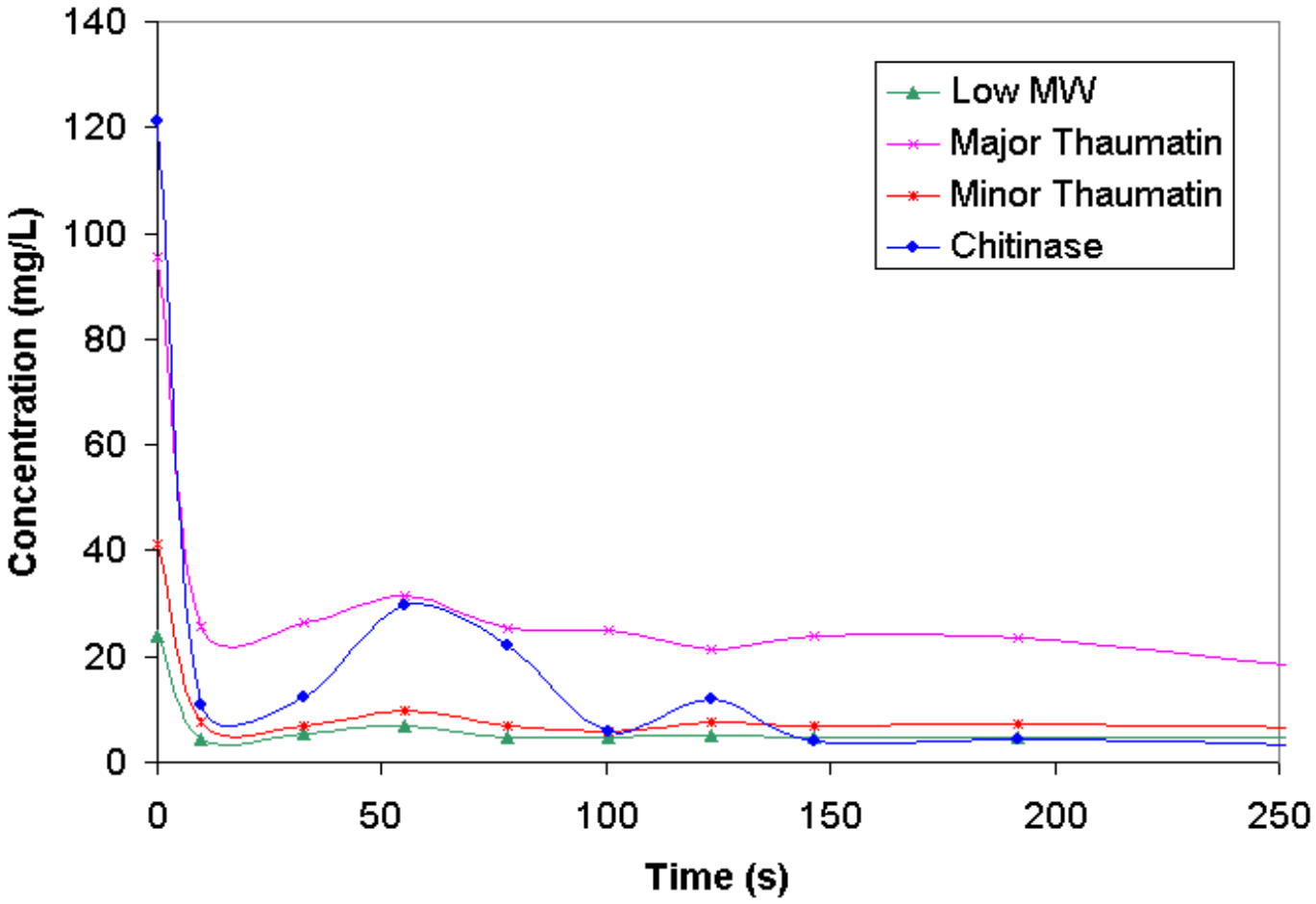
- Continuous injection of bentonite slurry into wine pipeline under turbulent flow
- Adsorption takes place in the "Contacting Zone"
- Continuous separation by centrifugation



Inline Dosing – Field Trials



Inline Dosing - Field Trial Results



Inline Dosing - Simulation

Bulk-phase in fluid

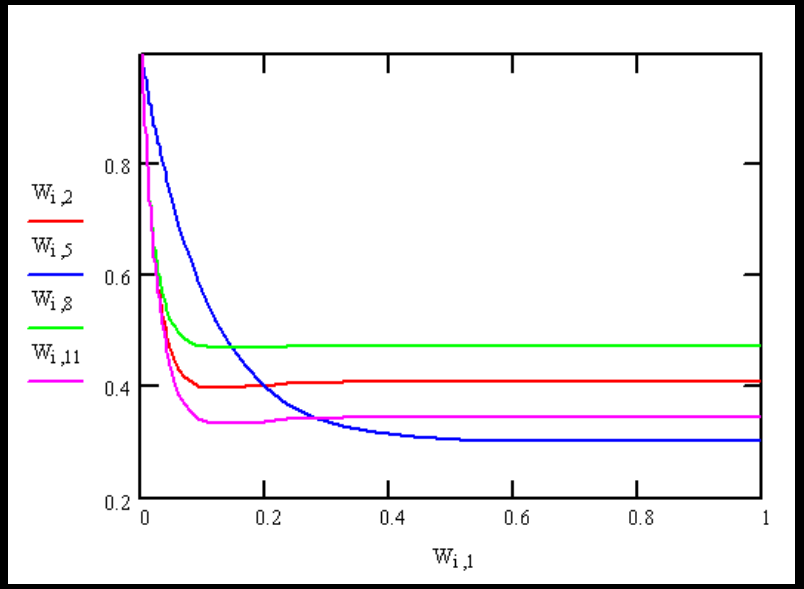
$$\frac{dc_i}{d\tau} = -k_i\, a\, \frac{L}{v}\, (c_i - c_{pi})$$

Bulk-phase adjacent particle surface

$$\frac{dc_{pi}}{d\tau} = \xi_i\, (c_i - c_{pi}) - \frac{dc^s_{pi}}{d\tau}$$

Particle surface

$$\frac{dc^s_{pi}}{d\tau} = \frac{k_{ai}\, C_{0i}\, L}{v}\, c_{pi} \left(c^{\infty}_{pi} - \sum_{i=1}^{N_S} \theta_{ij}\, \frac{C_{0j}}{C_{0i}}\, c^s_{pj} \right) - \frac{k_{di}\, L}{v}\, c^s_{pi}$$



Simulation Example

Economic Analysis

Standard unit wine cost: $2 / L

Analysis accounts for:

- Quality downgrade
- Wine loss
- Bentonite / Proctase
- Energy
- Labour

Economic Analysis

Treatment cost per L:

Commercial-scale trial	Sauv Bl	Chard	Riesling
Batch Bentonite addition	$ 0.0194	$ 0.0156	$ 0.0106
Inline Bentonite addition	$ 0.0032	$ 0.0030	$ 0.0038
Heating + Proctase	$ 0.0053	$ 0.0052	$ 0.0051

Summary

- Bentonite properties affect performance
- Performance can be modified by thermal treatment
- Inline dosing can provide a cost saving to larger producers with access to centrifuge equipment and long pipe runs
- For smaller producers, proctase is likely to be a better option

Summary

- Inline dosing can provide a cost saving to larger producers with access to centrifuge equipment and long pipe runs

- For smaller producers, proctase is likely to be a better option

Acknowledgements

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