

Algae Autocoagulation

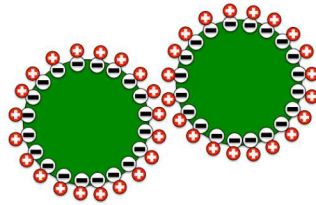
Pat Brady

Senior Scientist,

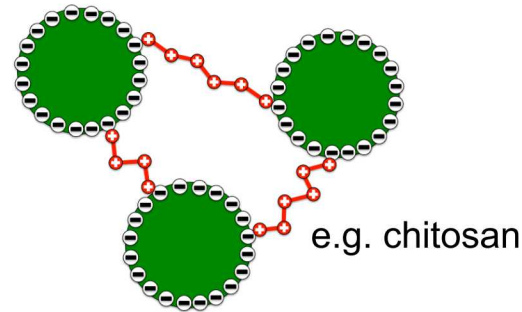
Sandia National Laboratories

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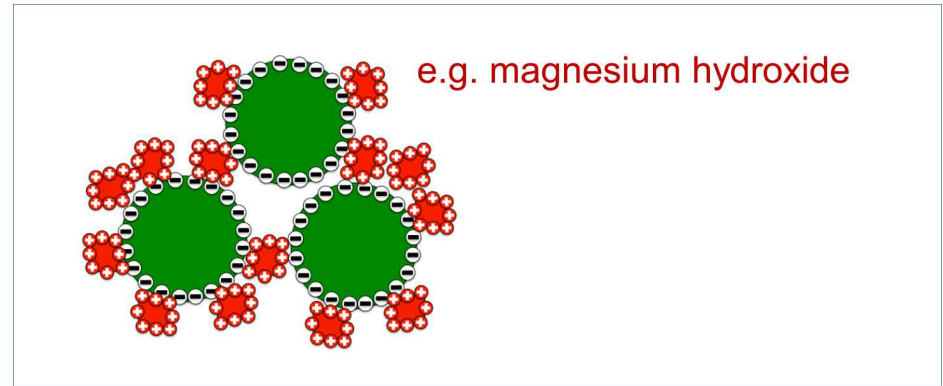
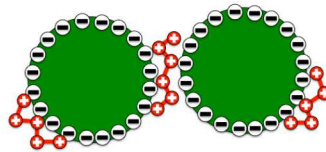
Charge neutralisation



Bridging



Electrostatic patch mechanism



Our Focus

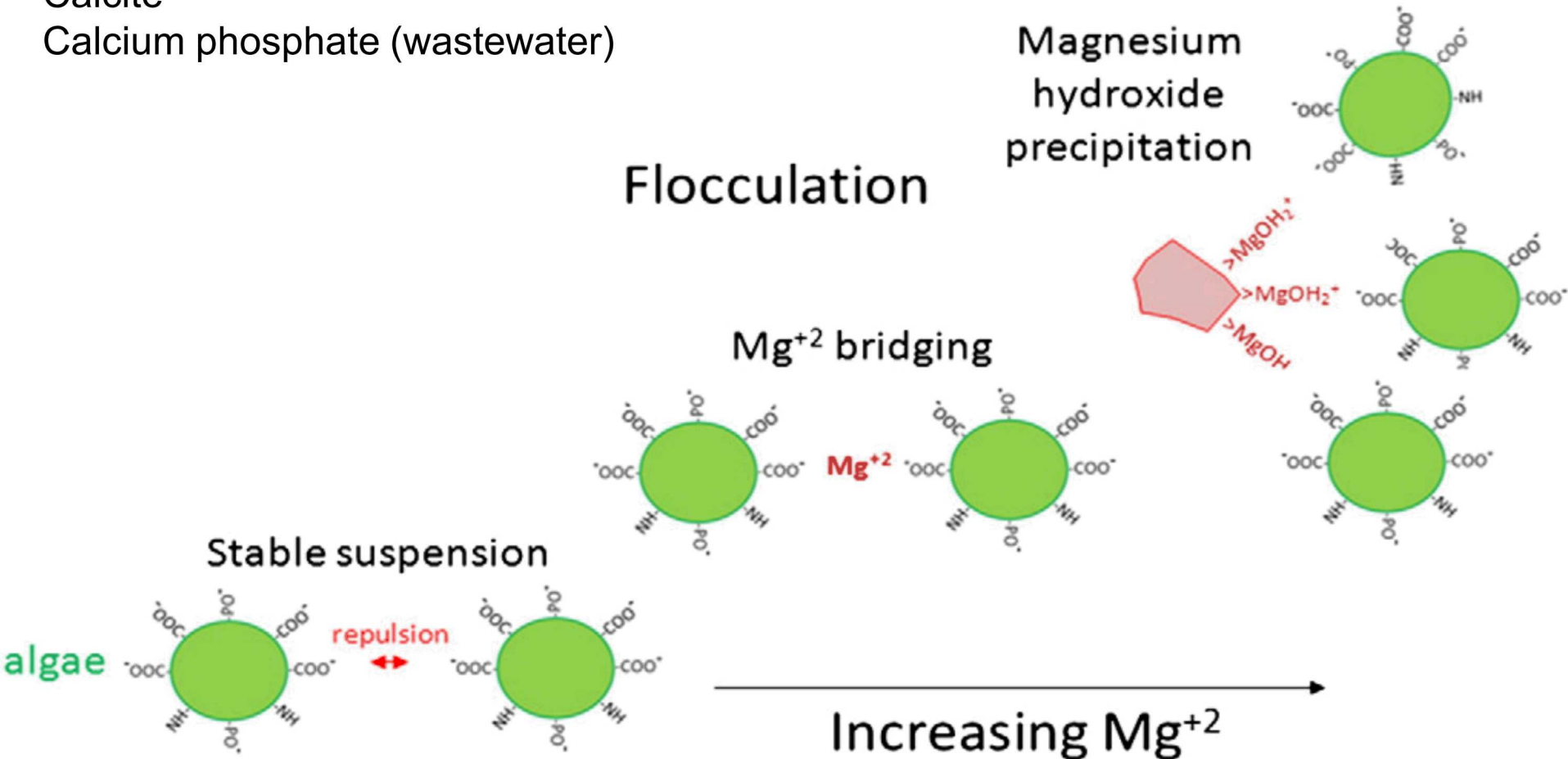
From: Muylaert, Koenraad, Dries Vandamme, Imogen Foubert, and Patrick V. Brady. "Harvesting of microalgae by means of flocculation." In *Biomass and Biofuels from Microalgae*, pp. 251-273. Springer, Cham, 2015.

Autoflocculants

Magnesium Hydroxide

Calcite

Calcium phosphate (wastewater)

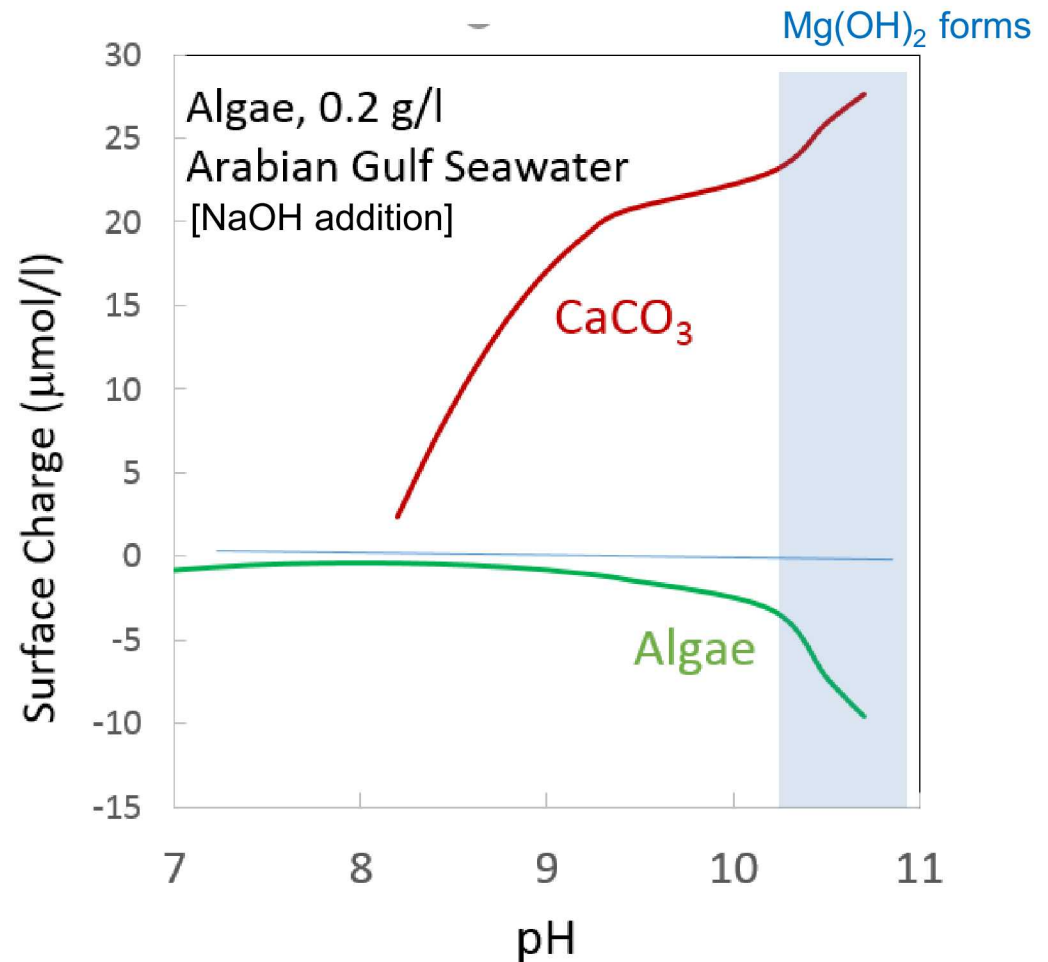
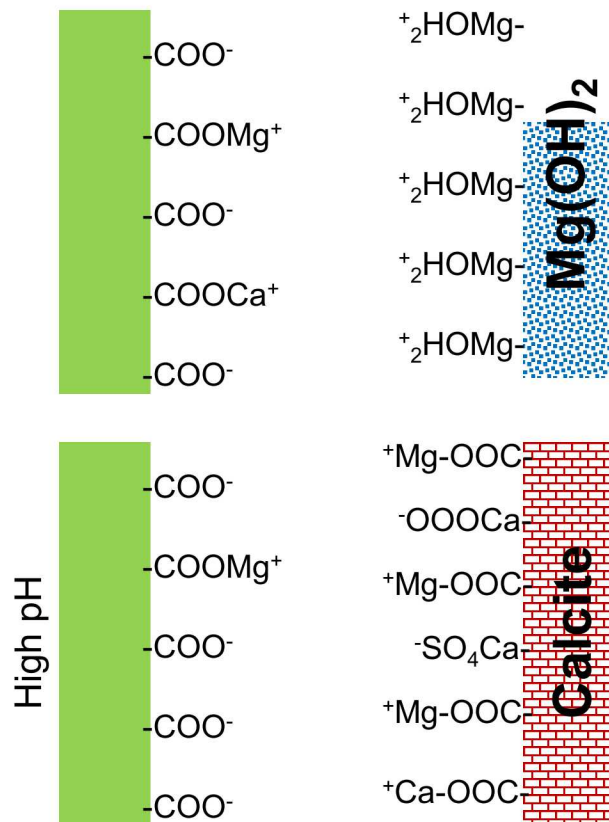


from: Brady, Patrick V., Phillip I. Pohl, and John C. Hewson. "A coordination chemistry model of algal autoflocculation." *Algal Research* 5 (2014): 226-230.

25 °C log K		
<i>Algae</i>		
1	$-\text{COOH} \leftrightarrow -\text{COO}^- + \text{H}^+$	-5.5
2	$-\text{POH}^- \leftrightarrow -\text{PO}^{-2} + \text{H}^+$	-7.7
3	$-\text{OH} \leftrightarrow -\text{O}^- + \text{H}^+$	-9.9
4	$-\text{COOH} + \text{Ca}^{+2} \leftrightarrow -\text{COOCa}^+ + \text{H}^+$	-3.8
5	$-\text{COOH} + \text{Mg}^{+2} \leftrightarrow -\text{COOMg}^+ + \text{H}^+$	-3.5
6	$-\text{PO}^{-2} + \text{Ca}^{+2} \leftrightarrow -\text{POCa}$	2.7
7	$-\text{PO}^{-2} + \text{Mg}^{+2} \leftrightarrow -\text{POMg}$	2.9
<i>Mg(OH)₂</i>		
10	$>\text{MgOH}_2^+ \leftrightarrow >\text{MgOH} + \text{H}^+$	-10
11	$>\text{MgOH} \leftrightarrow >\text{MgO}^- + \text{H}^+$	-12
<i>Hydroxylapatite</i>		
12	$>\text{CaOH} + \text{H}^+ \leftrightarrow >\text{CaOH}_2^+$	8.41
13	$>\text{PO}_3\text{H}_2 \leftrightarrow >\text{PO}_3\text{H}^- + \text{H}^+$	-1.11
14	$>\text{CaOH} + \text{HPO}_4^{-2} + \text{H}^+ \leftrightarrow >\text{CaPO}_4\text{H}^- + \text{H}_2\text{O}$	11.63
15	$>\text{PO}_3\text{H}_2 + \text{Na}^+ \leftrightarrow >\text{PO}_3\text{Na}^- + 2\text{H}^+$	-5.1
16	$>\text{PO}_3\text{H}_2 + \text{Ca}^{+2} \leftrightarrow >\text{PO}_3\text{HCa} + 2\text{H}^+$	-6.6
17	$>\text{PO}_3\text{H}_2 + \text{Mg}^{+2} \leftrightarrow >\text{PO}_3\text{Mg} + 2\text{H}^+$	-6.4
<i>Calcite surface/solution analogue</i>		
18	$>\text{CaOH} + \text{H}^+ \leftrightarrow >\text{CaOH}_2^+$	^a 11.8
19	$\text{Ca}(\text{OH})_2^{\text{aq}} + \text{H}^+ \leftrightarrow \text{CaOH}^+ + \text{H}_2\text{O}$	^a 11
20	$>\text{CaOH} + \text{H}^+ + \text{CO}_3^{-2} \leftrightarrow >\text{CaCO}_3^- + \text{H}_2\text{O}$	17.1
21	$\text{Ca}(\text{OH})^+ + \text{H}^+ + \text{CO}_3^{-2} \leftrightarrow \text{CaCO}_3^{\text{aq}} + \text{H}_2\text{O}$	16.6
22	$>\text{CaOH}_2^+ + \text{SO}_4^{-2} \leftrightarrow >\text{CaSO}_4^- + \text{H}_2\text{O}$	2.1
23	$\text{Ca}^{+2} + \text{SO}_4^{-2} \leftrightarrow \text{CaSO}_4^{\text{aq}} + \text{H}_2\text{O}$	2.1
24	$>\text{CO}_3\text{H} \leftrightarrow >\text{CO}_3^- + \text{H}^+$	-5.1
25	$^{\text{c}}\text{H}_2\text{CO}_3^* \leftrightarrow \text{HCO}_3^- + \text{H}^+$	^b -5.1
26	$>\text{CO}_3\text{H} + \text{Ca}^{+2} \leftrightarrow >\text{CO}_3\text{Ca}^+ + \text{H}^+$	^c -2.6
27	$>\text{CO}_3\text{H} + \text{Mg}^{+2} \leftrightarrow >\text{CO}_3\text{Mg}^+ + \text{H}^+$	^d -2.6
28	$>\text{CaOH}_2^+ + \text{HPO}_4^{-2} \leftrightarrow >\text{CaHPO}_4^- + \text{H}_2\text{O}$	2.7
29	$\text{Ca}^{+2} + \text{HPO}_4^{-2} \leftrightarrow \text{CaHPO}_4$	2.7
30	$>\text{CaOH}_2^+ + \text{HPO}_4^{-2} \leftrightarrow >\text{CaPO}_4^{-2} + \text{H}^+ + \text{H}_2\text{O}$	-5.3
31	$\text{Ca}^{+2} + \text{HPO}_4^{-2} \leftrightarrow >\text{CaPO}_4^- + \text{H}^+$	-5.3

- ✓ Develop surface complexation models for algae and autoflocculants
- ✓ Test/Calibrate
- ✓ Use to design new coagulation recipes; identify “sweet spots” – optimal treatment targets.

Algae in the Arabian Gulf



after: Brady, Patrick V., Phillip I. Pohl, and John C. Hewson. "A coordination chemistry model of algal autoflocculation." *Algal Research* 5 (2014): 226-230.