Tailoring algal floc properties for more robust cyanobacteria removal during drinking water treatment

Never Stand Still Faculty of Engineering School of Chemical Engineering

Andrea Gonzalez-Torres, Josh Putnam, Bruce Jefferson, Richard Stuetz and **Rita Henderson**

ELSEVIER

Water Research

Volume 60, 1 September 2014, Pages 197–209

Examination of the physical properties of *Microcystis aeruginosa* flocs produced on coagulation with metal salts

A. Gonzalez-Torres[a], J. Putnam[b], B. Jefferson[c], R.M. Stuetz[b], R.K. Henderson[a]

Show more

DOI: 10.1016/j.watres.2014.04.046

Highlights

- *Microcystis aeruginosa* flocs were examined at varying alum and ferric coagulant doses at pH 6 and 7.
- Ferric-flocs grew faster to produce more compact, larger flocs in comparison with alum.
- Flocs formed at low dose (charge neutralisation) were more likely to reform if broken.
- Increasing coagulant dose (sweep floc) resulted in faster floc growth and stronger flocs.
- Algal organic matter may play a role as an inherent bioflocculant.

UNSW

Presentation outline

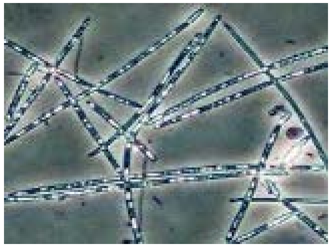
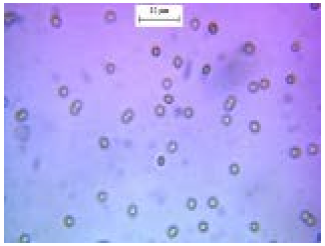
1. Problems involved with coagulation of cyanobacterial cells
2. Physical floc properties
3. Aim of the study
4. Material and methods
5. Results
6. Conclusion
7. Ongoing work

Cyanobacteria outbreak

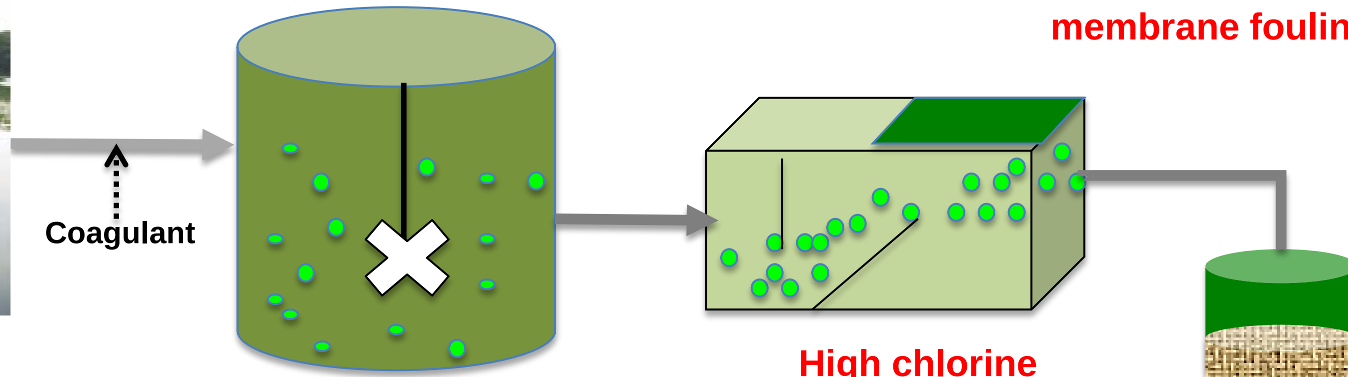
Elevated cyanobacterial concentrations throughout warmer months

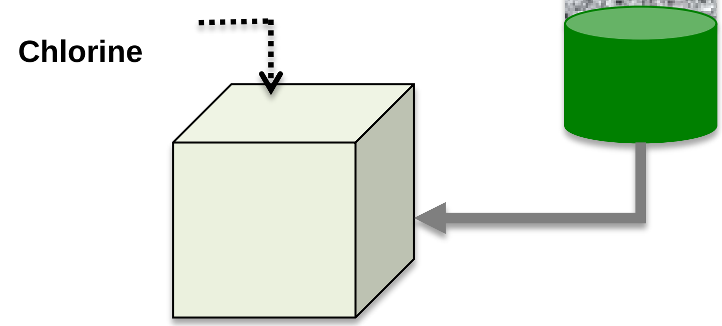
Cyanobacteria is difficult to control : morphology, changes in algogenic organic matter, coagulation conditions

2. Why is cyanobacteria a problem ?



High chlorine demand



- Taste and odour problems
- Production of disinfection by products
- Release of toxins

Reduced effluent quality

Physical floc properties

- Assessment of floc structure

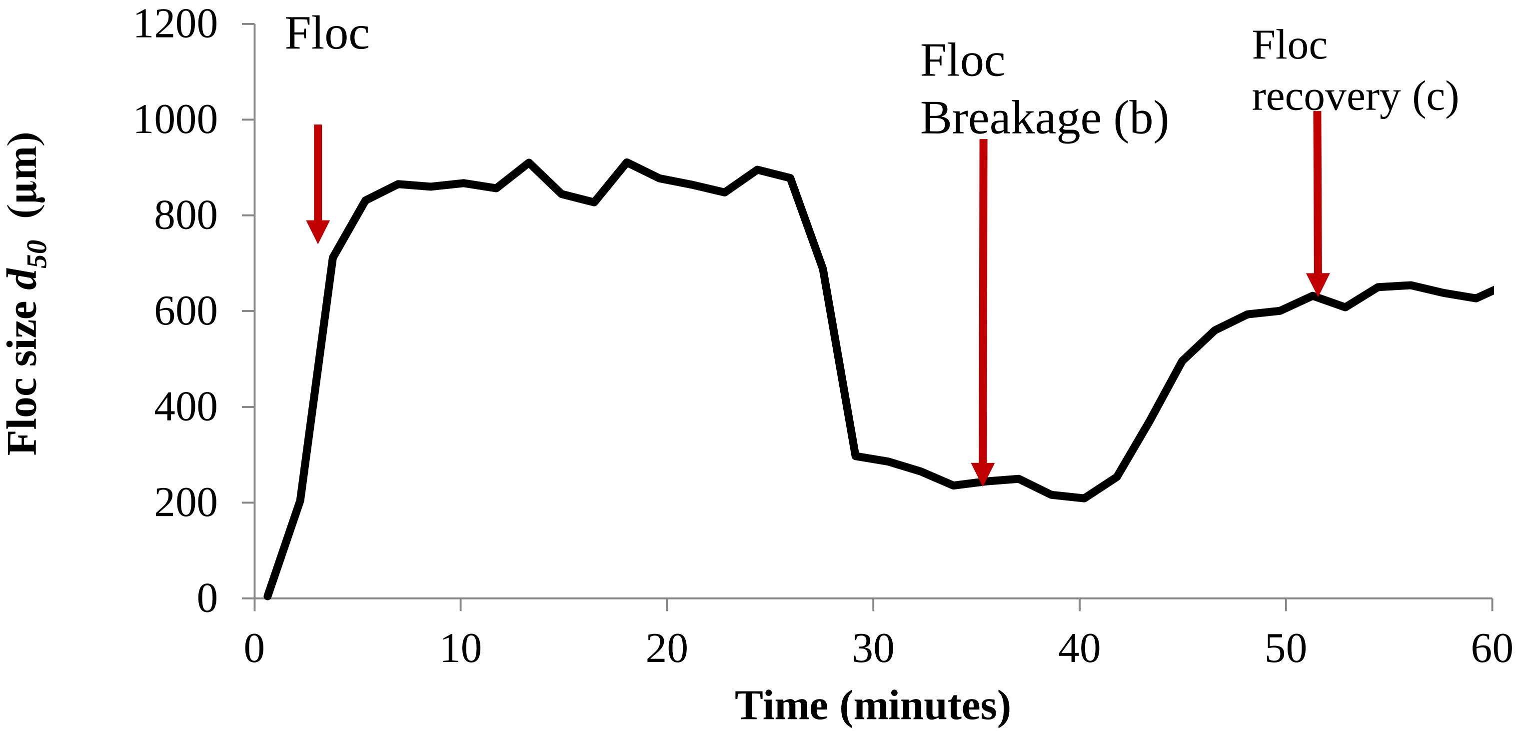
Parameter	Technique
Floc size	Light scattering, image analysis
Floc strength	Ultrasonic, empirical techniques

- Strength factor: indicative of floc strength
- Recovery factor: indicative of the capacity of to regrowth

Physical floc properties

*Strength factor (%)=100*b/a*

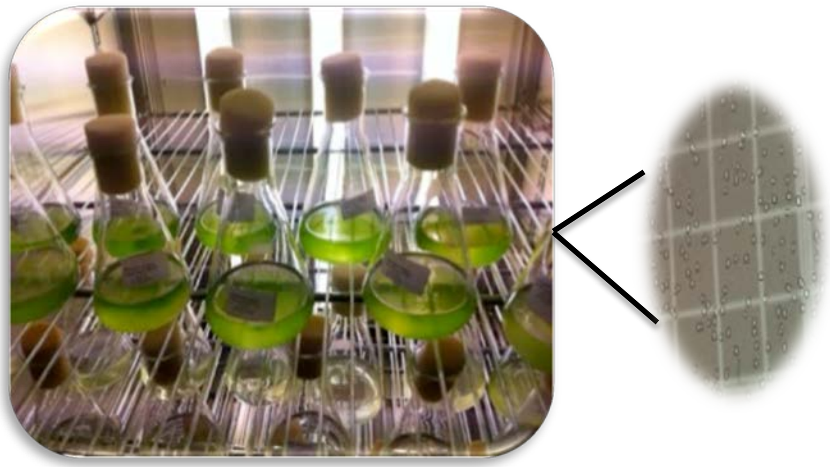
Recovery factor (%)=100(c-b)/(a-b)*

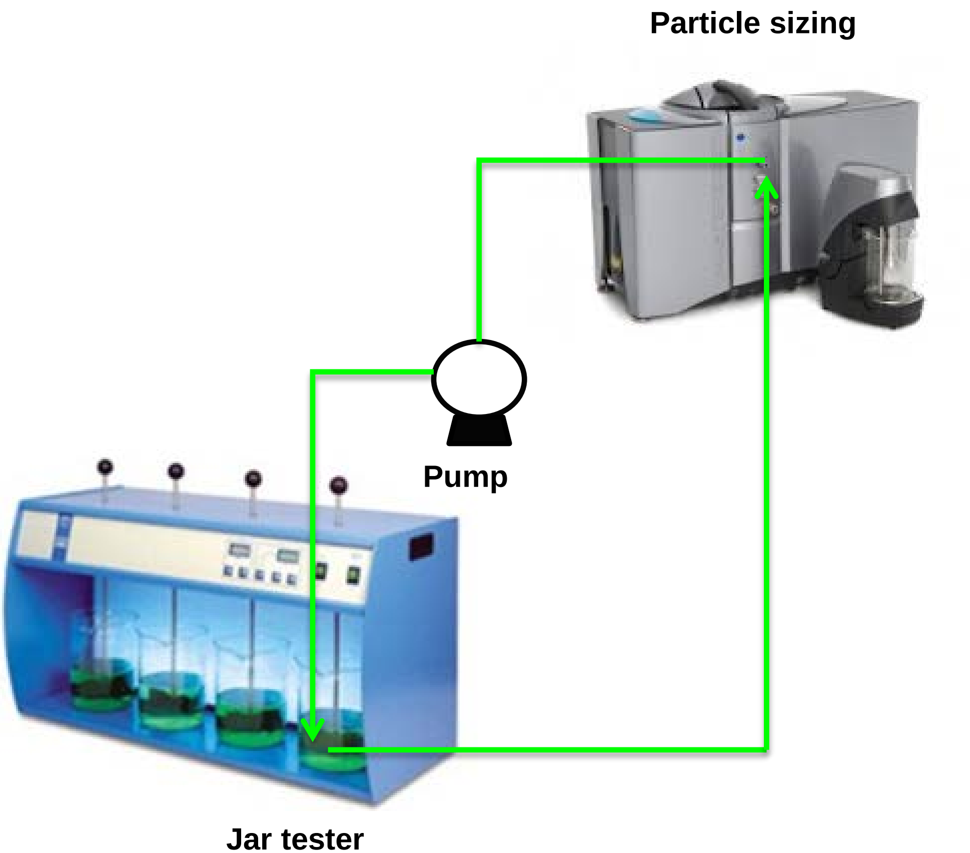


Aim of the study

To advance knowledge of how coagulation conditions impact cyanobacterial floc properties in order to improve removal by C-F process and downstream separation treatment

Materials and methods





- *M.aeruginosa*, late exponential phase (10-12 days)
- Ferric chloride and alum used as coagulants

Method - jar testing

Cyanobacteria suspension (*M.aeruginosa*, late exponential stage)

↓

2 min rapid mix at 200 rpm, adding coagulant, variable pH

Optimal dose determination

↓

Slow mixing at 30 rpm (25 min)

↓

Settling (30 min)

Floc properties analysis

↓

Mixing at 30, 45, 60, 90, 150 or 200 rpm (20 min)

↓

Slow mixing at 30 rpm (30 min)

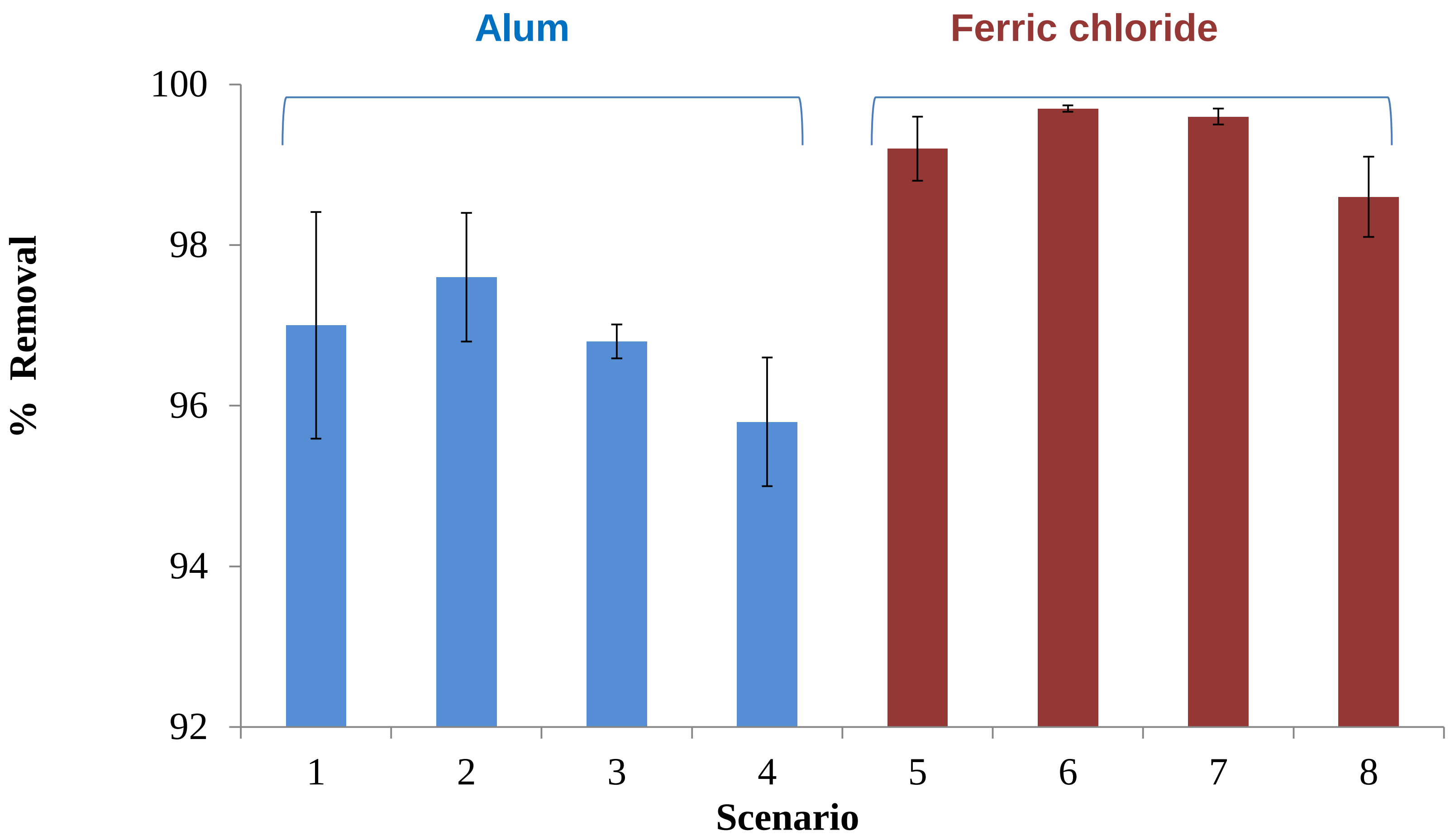
Scenarios studied

Coagulant	Scenario	Dose (mgL^{-1} as Al or Fe)	Predominant coagulation mechanism	pH
Alum	1	0.7	CN	6
	2	1	**CN-SF**	7
	3	5	SF	6
	4	4	SF	7
Ferric chloride	5	1	CN	6
	6	1	**CN-SF**	7
	7	7	SF	6
	8	7	SF	7

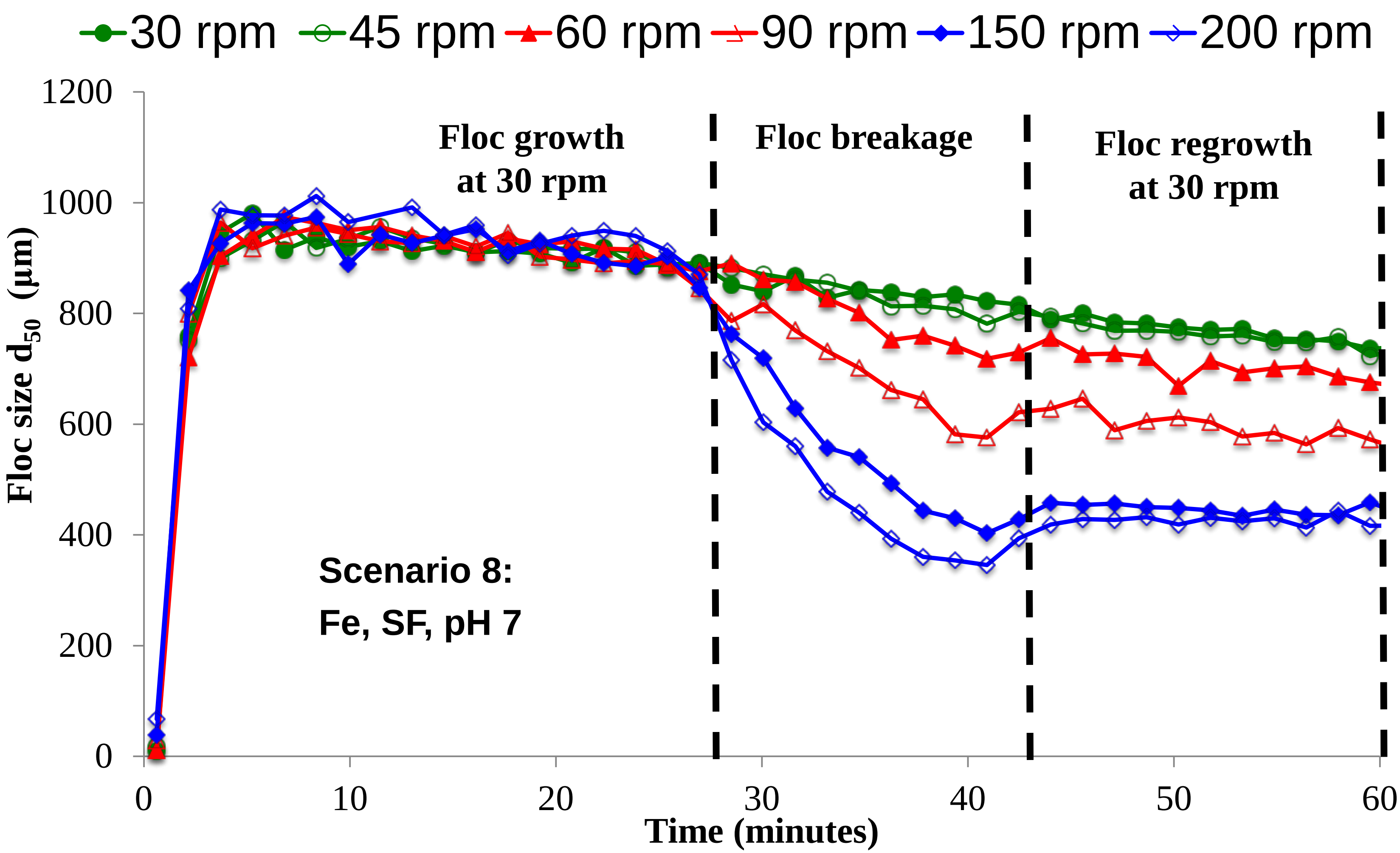
- ***Charge neutralisation (CN):*** neutralisation of particles by electrostatic forces; low pH and coagulant dose used; (+) low coagulant demand; (-) difficult to control.

- ***Sweep flocculation (SF):*** contaminants incorporated in amorphous hydroxide precipitates; high coagulant and pH;(+) easy to control (-) high coagulant demand.

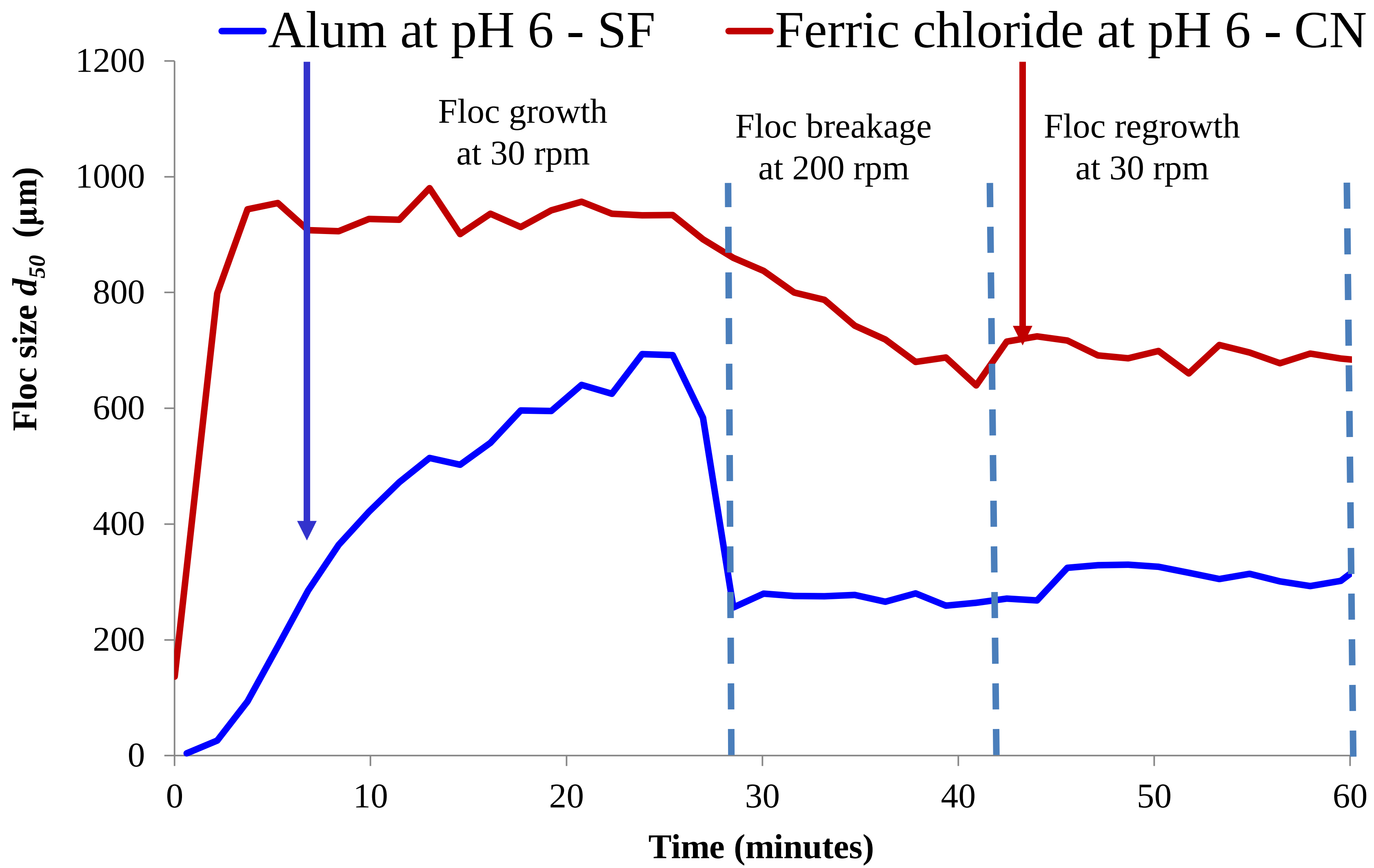
Ferric chloride is more efficient in removing algae than alum



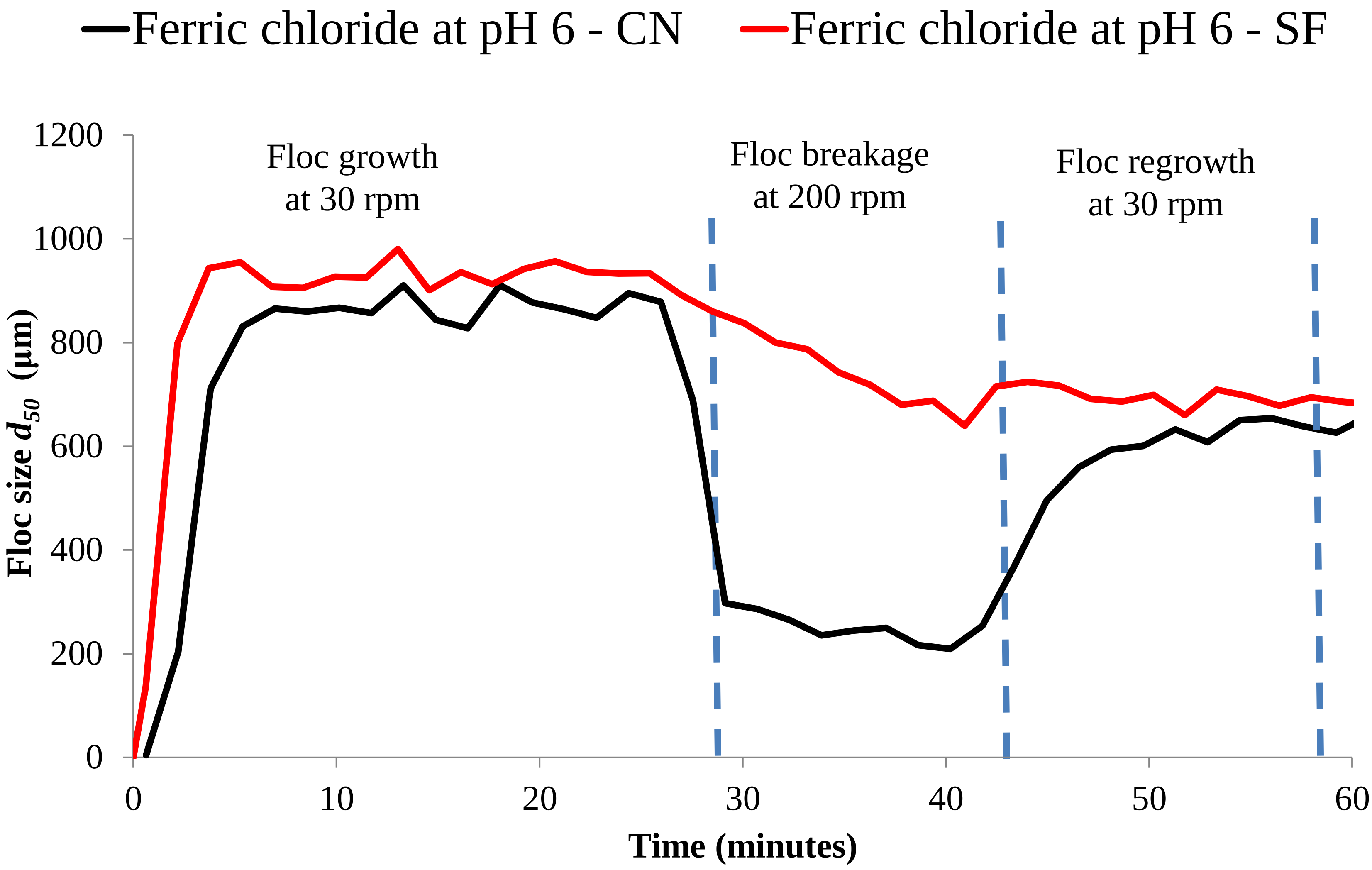
Floc growth profile: (i) Flocs tend to resist breakage
(ii) After breakage cannot reach initial floc size



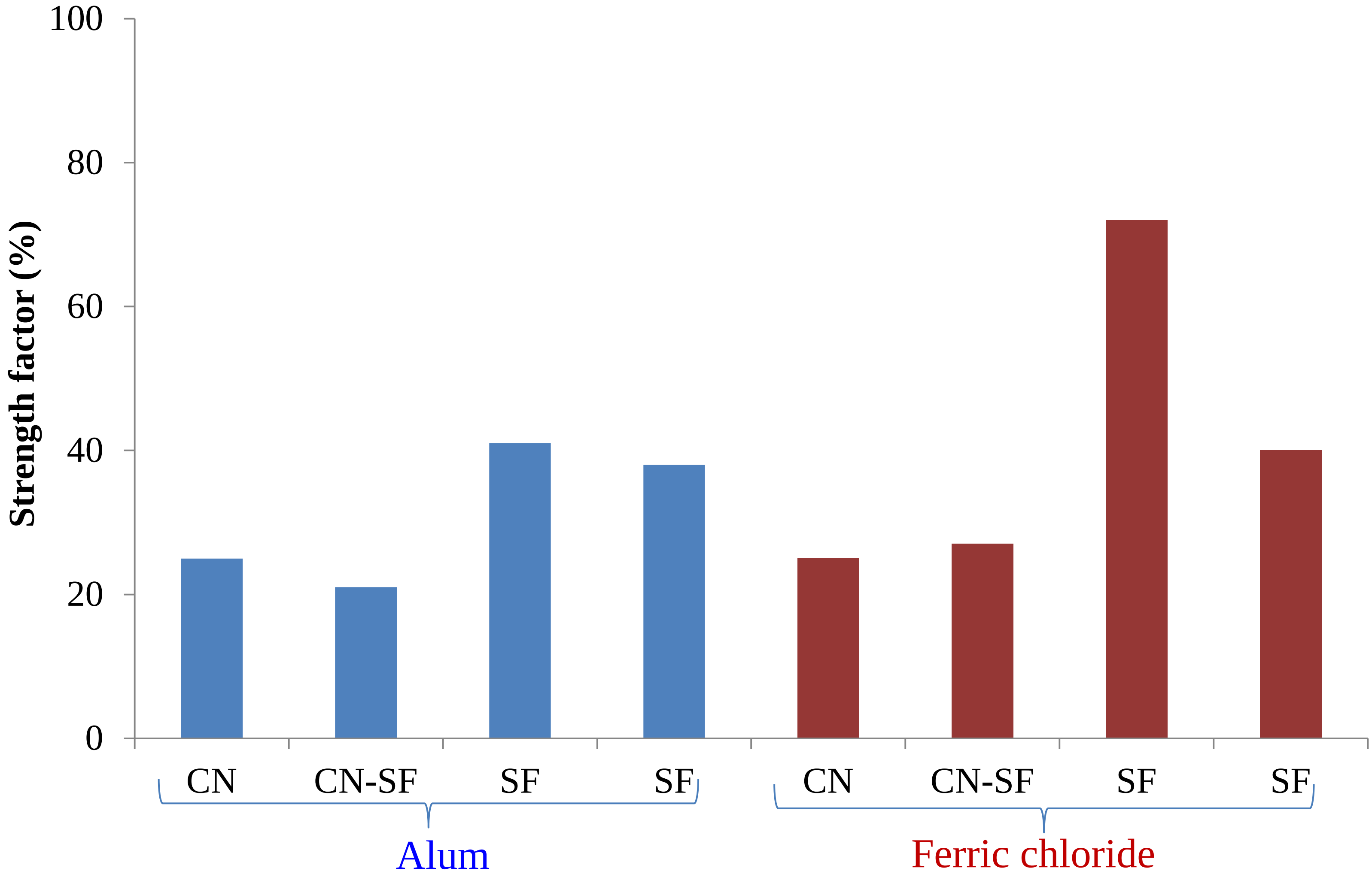
Ferric chloride produced larger flocs than alum



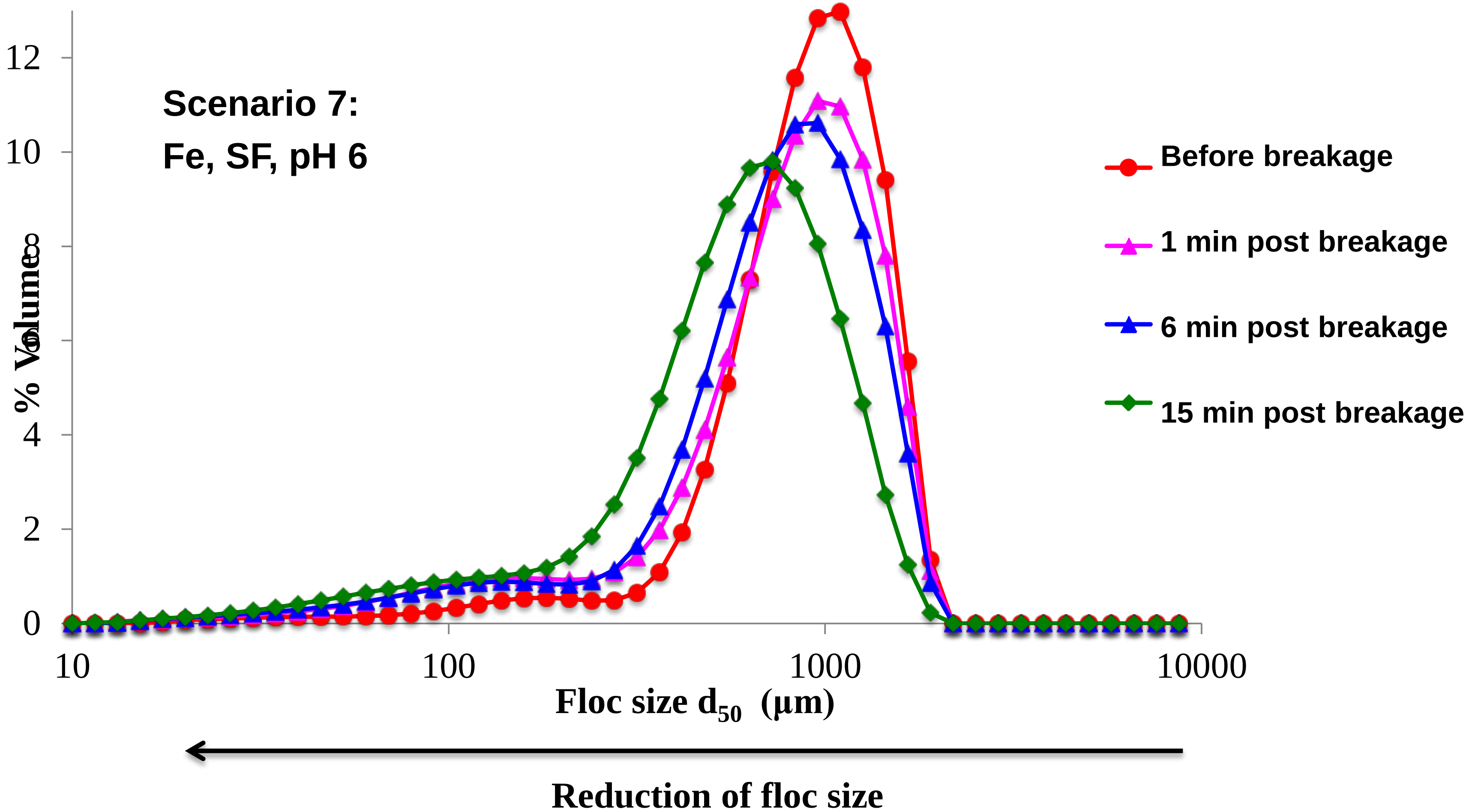
SF produced larger flocs with lower capacity to regrow



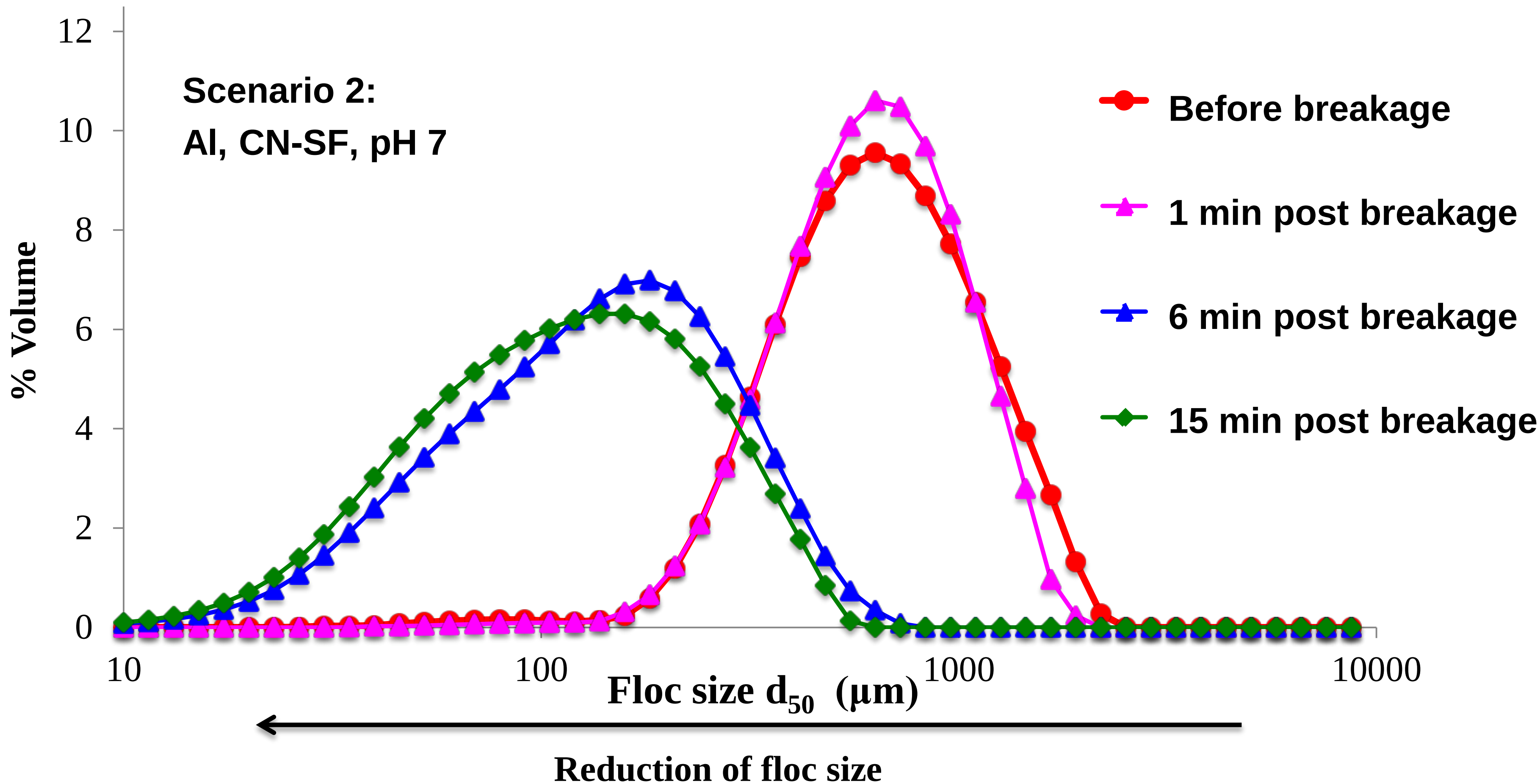
SF flocs were stronger than CN flocs



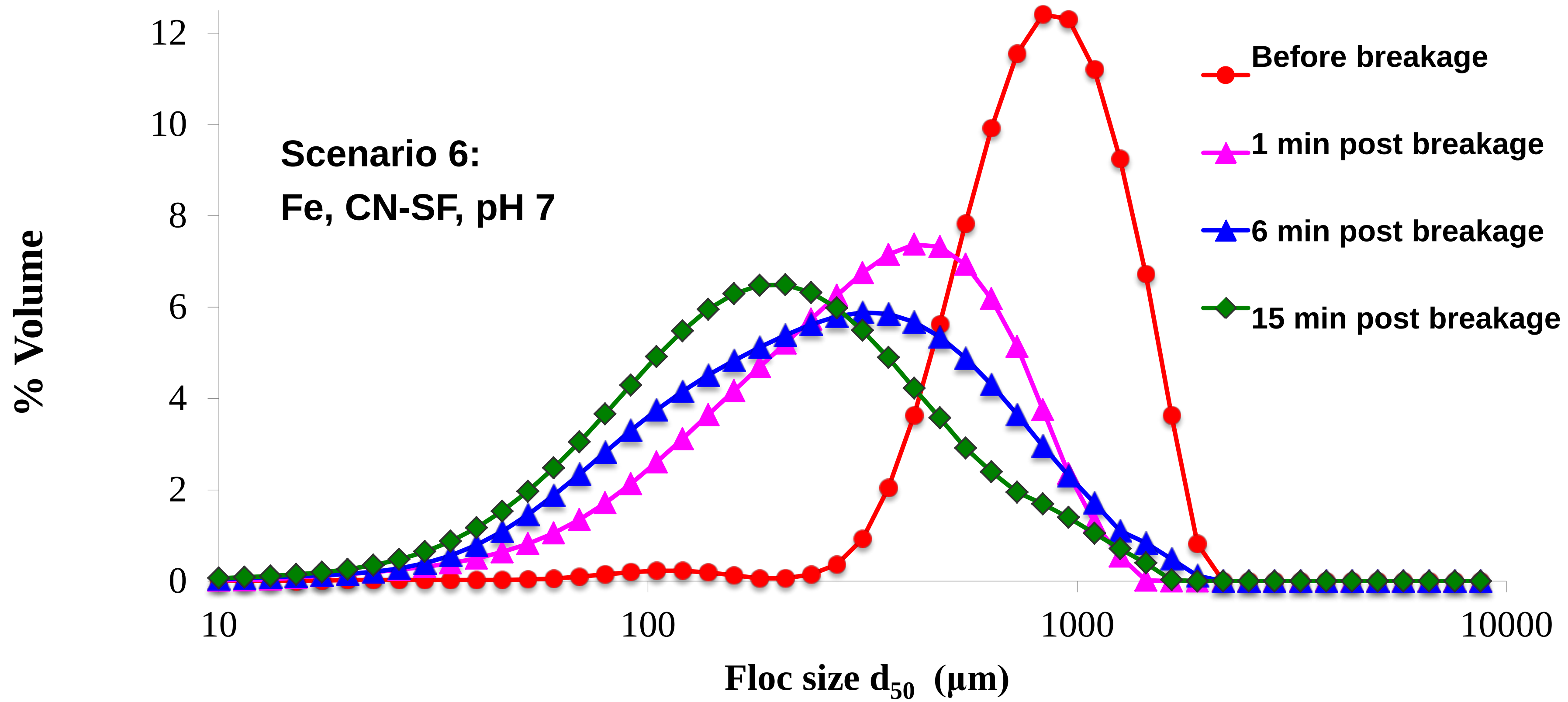
Three breakage mechanisms were identified:
1. Erosion



2. Delayed fragmentation followed by erosion



3. Fragmentation and erosion



Reduction of floc size

So what are the best coagulation conditions to remove cyanobacteria in drinking water?

Conclusions

- By improving our understanding of how to tailor floc properties for more efficient, robust separation of algal cells, we will be able to improve cyanobacteria removal in drinking water.
- Use of ferric as a coagulant is more suitable for use with sedimentation as a downstream process.
- Use of alum as a coagulant is more suitable for use with DAF as a downstream process.

Ongoing work

- Studying physical floc properties obtained by using other types of coagulants and using algal species.
- Using spectroscopic techniques to analyse cyanobacteria chemical floc properties.

Acknowledgements

Water Quality Research Australia (WQRA).

Mareva Marietti.

`