Causes of aerobic granule disintegration under high organic loading and potential approach to maintain granule stability

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Introduction

Aerobic granulation has become a promising technology for sustainable wastewater treatment, due to its excellent sludge settleability, high treatment capacity and high resilience to toxins[1]. Granule disintegration is a major challenge for the full-scale application of aerobic granulation technology. It has been confirmed by a number of research that deterioration in granule stability occurs under high organic loading rates (OLR), especially over 20 g COD/L·d[2-4]. **Microbiological and molecular techniques** were used in this study to investigate the mechanisms behind granule disintegration. Some operational conditions such as **increased phosphorus loading** may help to maintain stable granules and **precursors** can potentially be detected before disintegration occurs.

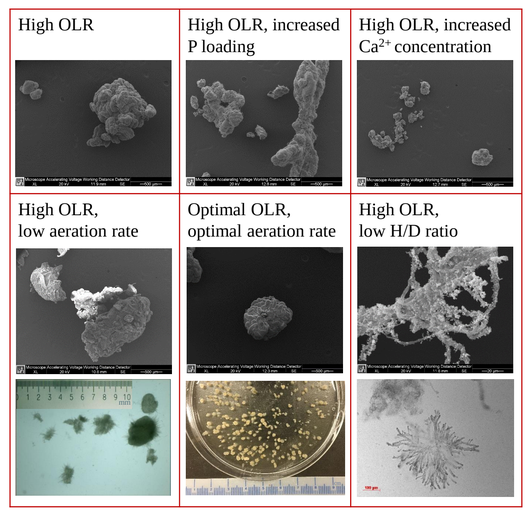
Reactor Setup

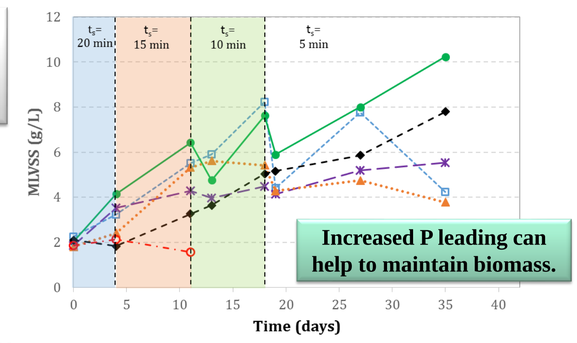
R1 (target condition): OLR = 8 g COD/L·d, C:N:P ratio = 100:5:1, aeration rate = 2.8 cm/s, Ca^{2+} concentration = 8.1 mg/L, settling time = 5 min, reactor height/diameter ratio = 12.

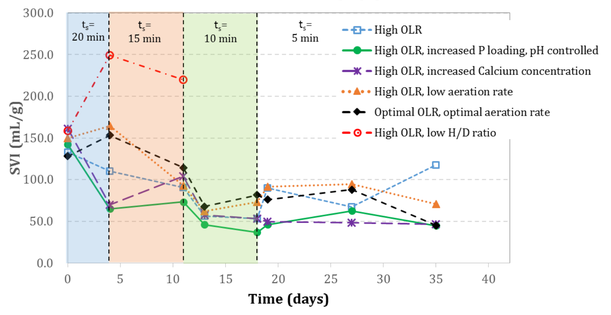
Reactor	Conditions different from target
R2	C:N:**P** ratio = 100:5:2
R3	**Ca^{2+}** concentration = 50 mg/L
R4	**Aeration rate** = 1.6 cm/s
R5	**OLR** = 5.2 g COD/L·d
R6	**Settling time** = 20 min, reactor **height/diameter ratio** = 1

Granule and Mixed Liquor Characteristics

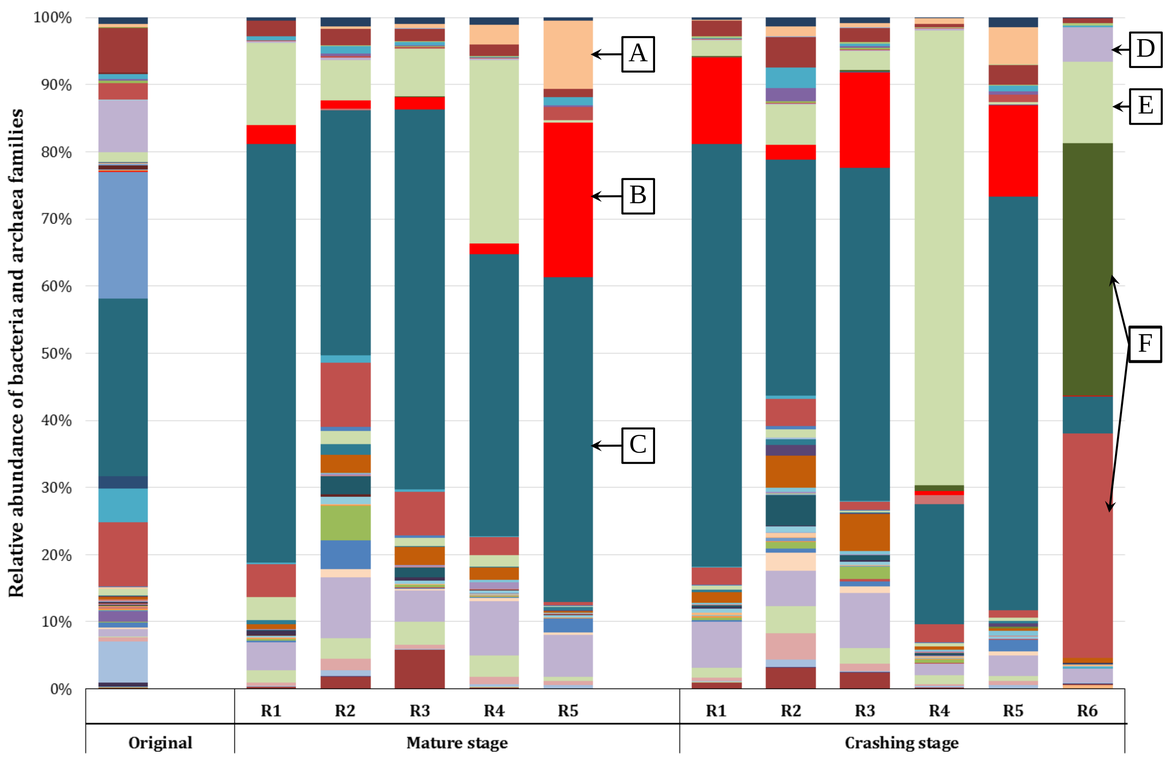
Under optimal OLR, healthy and stable granules formed;
Under high OLR, granules disintegrated quickly after formation;
Low aeration lead to significant overgrowth of filaments;
Without granulation, reactor crashed quickly due to bulking.







Microbial Community



A: Facultatively anaerobic bacteria (Including Denitrifiers)

B: Predators

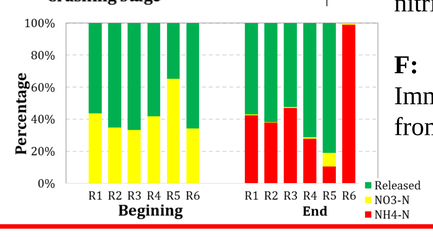
C: Exopoly-saccharide production

D: COD removal bacteria

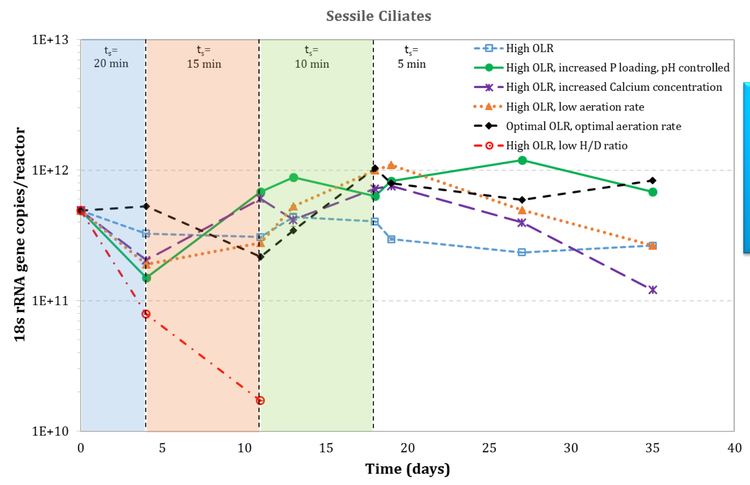
E: Nutrient removal bacteria (Including Heterotrophic nitrifiers)

F: Immigration from sewage

Healthy and stable granules ↔ well balanced community
Less viscous EPS production ↔ Fewer Exopolysaccharide production species
In mature granules, denitrification activity observed ↔ Presence of denitrifiers
Better ammonia removal after granulation ↔ Presence of heterotrophic nitrifiers
Poor performance ↔ Reduction of functional bacteria groups

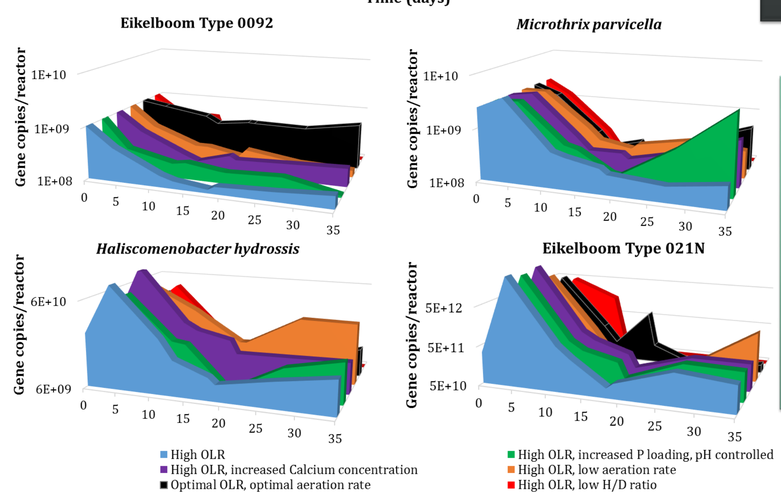


Indicators and precusors



Reduction of sessile ciliates can be an indicator for the loss of granule stability.

Stable quantity of Type 0092 filaments may be an indicator of good granule stability.



Increase of filaments *H. hydrossis* can be a precursor of granule disintegration, which can be detected before disintegration occurred.

Conclusions

- Without granulation, bulking occurred much faster and lead to reactor crash under high OLR.
- High OLR results in high F/M ratio which can cause granule disintegration due to either filamentous bulking or viscous bulking.
- Increased phosphorus loading can significantly reduce viscous bulking and change filaments community, which can help with biomass retain.
- Sessile ciliates and certain filaments can be used as indicators/precursors for granule disintegration.
- Microbiological and molecular techniques can be a very useful tool to study the mechanisms of granule disintegration and to detect indicators and precursors.

References

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