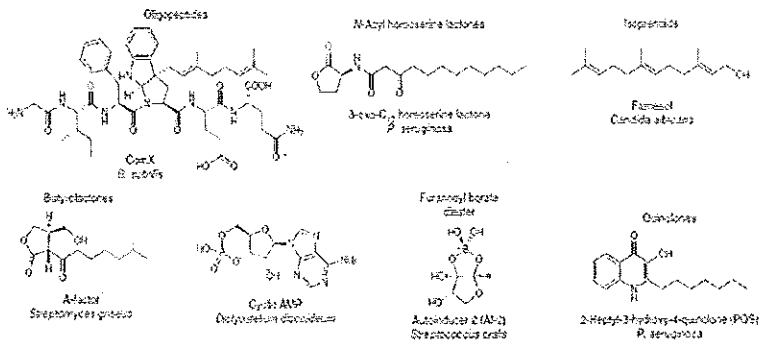
Aerobic microbial granulation: A story of cell-cell signalling

Quorum sensing signalling

Quorum sensing (QS) signalling is the ability of bacteria to coordinate social behaviour by responding to small diffusible chemical molecules produced and released into the immediate environment by the population of its own kind or others



Phelan *et al.* 2011 Nat Chem Biol

2

Proposed role of QS signalling in mixed microbial communities

Enhanced phenol degradation and change of community composition
Valle *et al.* 2004 Environmental Microbiology

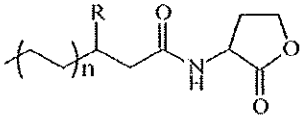
Enhanced chitinase activity
Chong *et al.* 2012 Microbial Biotechnology

Enhanced anoxic ammonium oxidation rate
De Clippelier *et al.* 2011 Applied Microbiology and Biotechnology

Nutrient/energy acquisition

Formation of biofilms in a membrane bioreactor (MBR)
Yeon *et al.* 2008 Environmental Science and Technology

Biofilm development



N-Acyl homoserine lactones (AHLs)

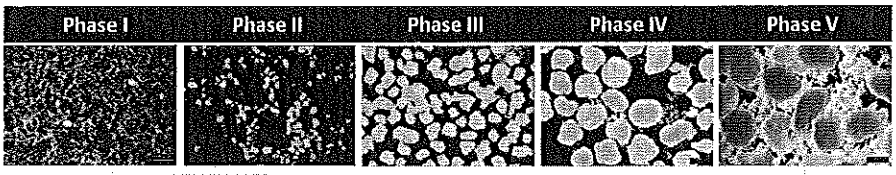
Acyl side chain = 4 – 18 carbons
R = H/O/OH
Presence of double bond(s)

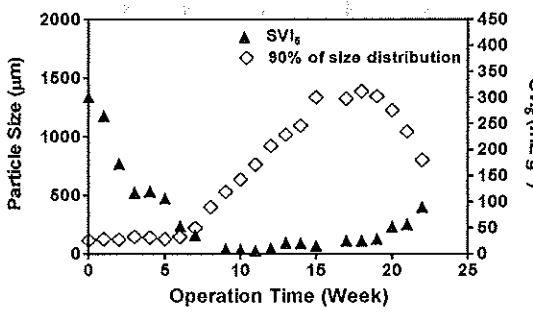
3

Community QS signalling
In microbial granulation system

4

Developmental process of a granular microbial community

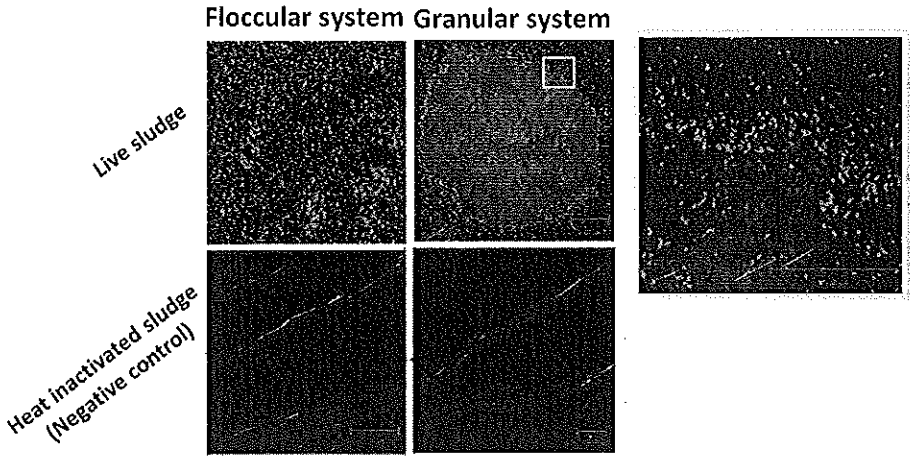




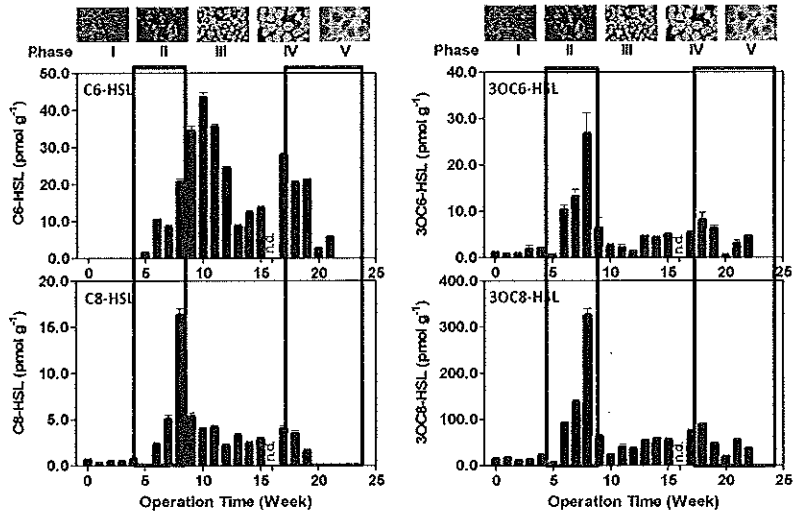
- SNDPR system
- Assessed by
  - Stereomicroscopy
  - Particle size distribution
  - SVI_5

5

Visual confirmation of *in situ* AHL-mediated QS signalling in floccular and granular sludge communities

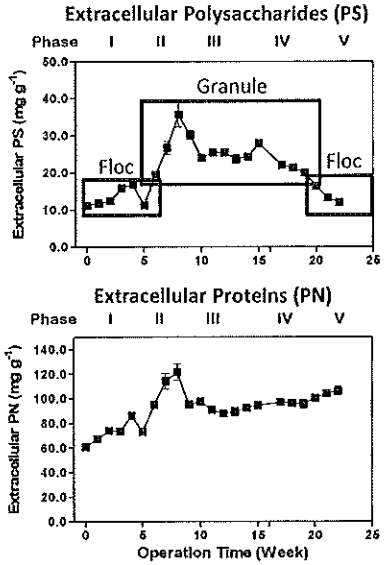


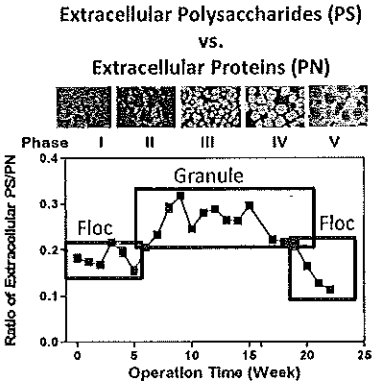
AHL increases during the initiation of granule formation and decreases during the granule dispersal



7

EPS profiling of the granular microbial community



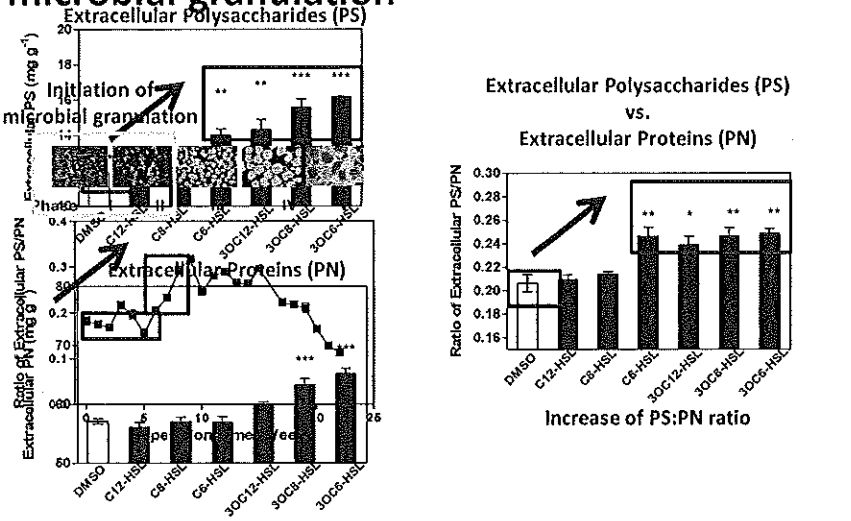


EPS: Extracelullar Polymeric Substances

8

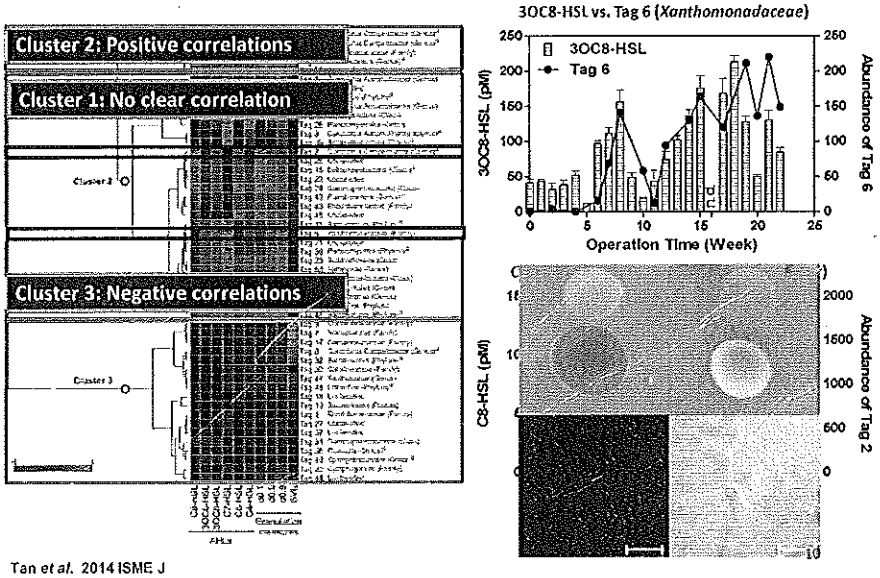
AHL addback-induced EPS production supports signalling-mediated initiation of microbial granulation

Addback of specific AHLs to flocculant sludge drives EPS production



9

QS and granular metagenome community composition



Tan *et al.* 2014 ISME J

Summary

QS signalling may drive the initiation of granule formation through QS-mediated EPS production

QS signaling may also be important in the maintenance of mature granules; without QS signalling the community organization disintegrates

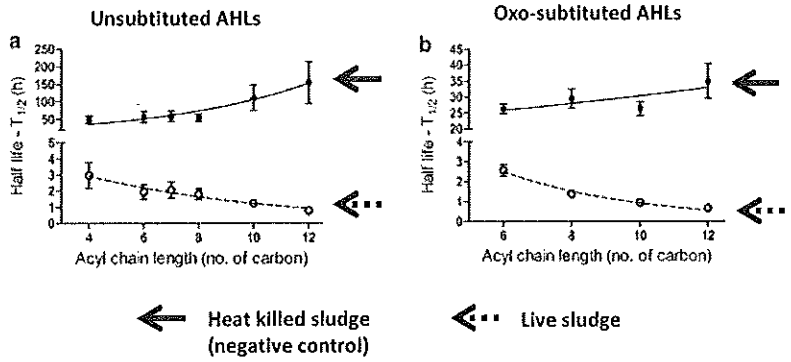
Identification of specific community members of the metagenome involved in QS; including organisms previously assigned as QS producers, as well as those suggested as key for granulation here shown to be QS associated

11

Modulation of community QS signalling

12

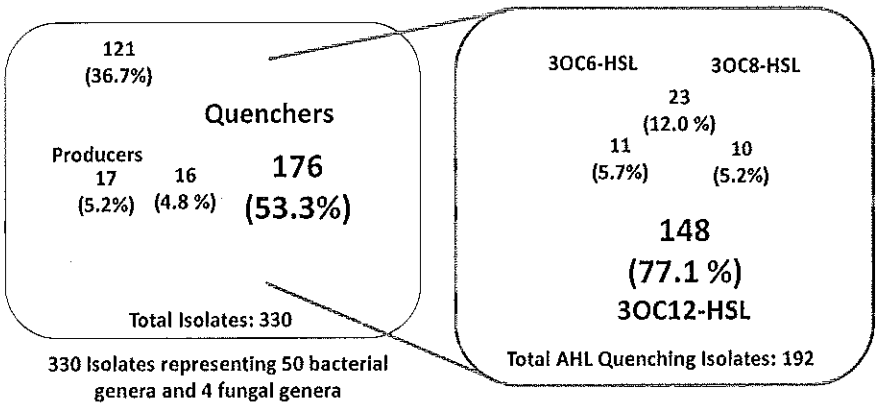
Rapid AHL degradation by the floccular sludge community



- Degradation of exogenously added AHLs is mediated by microbial QQ activity @ pH 6.7
- The rate of signal degradation is a function of acyl chain length
- The contribution of chemical signal degradation or physical signal absorption is minimal

13

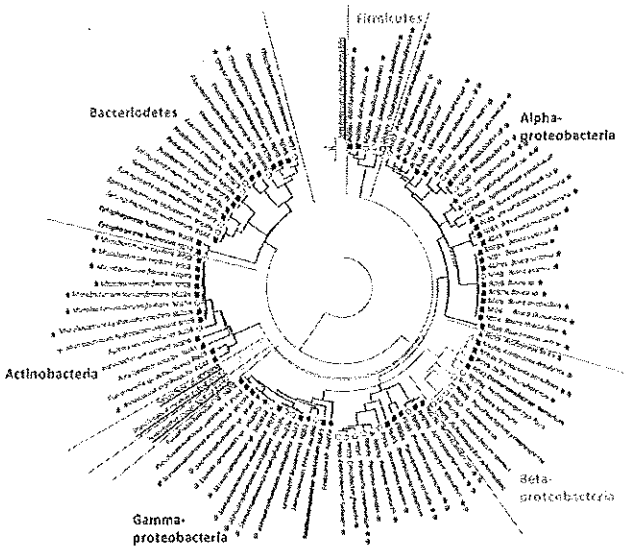
Members of floccular sludge community predominantly either produce or quench AHLs



The 330 isolates account for 3.5% of total metagenomic community members

14

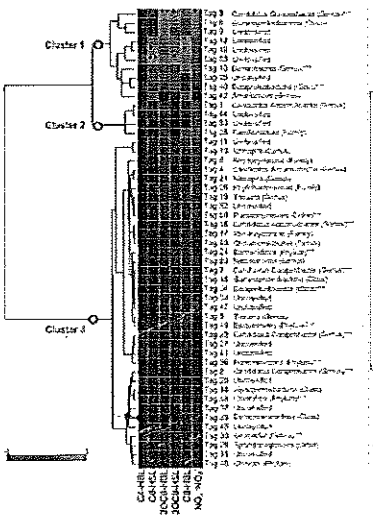
Phylogeny of AHL producing and quenching bacteria from floccular sludge community



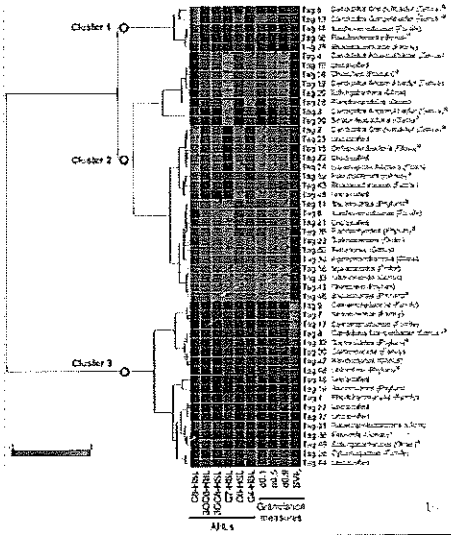
15

Distinct difference between community QS signalling in floccular vs. granular systems

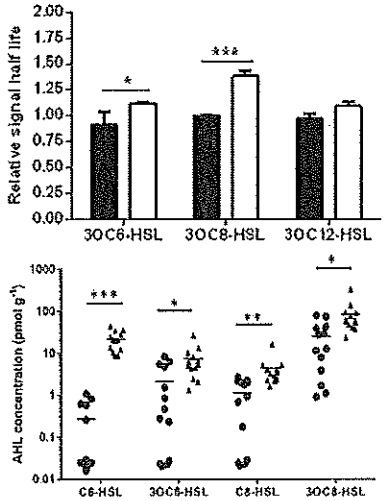
Floccular system



Granular system



QQ activity at the floccular stage suppresses the accumulation of AHLs



Tan *et al.* 2015 npj Biofilms and Microbiomes

17

Summary

The QS signalling control system at the community level is characterized by gradient signal degradation kinetics where the AHLs are degraded based on the function of the acyl chain length.

AHL QS signaling is a true microbial community trait with up to 65% of community members participating in signal production and signal quenching activities.

18

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19