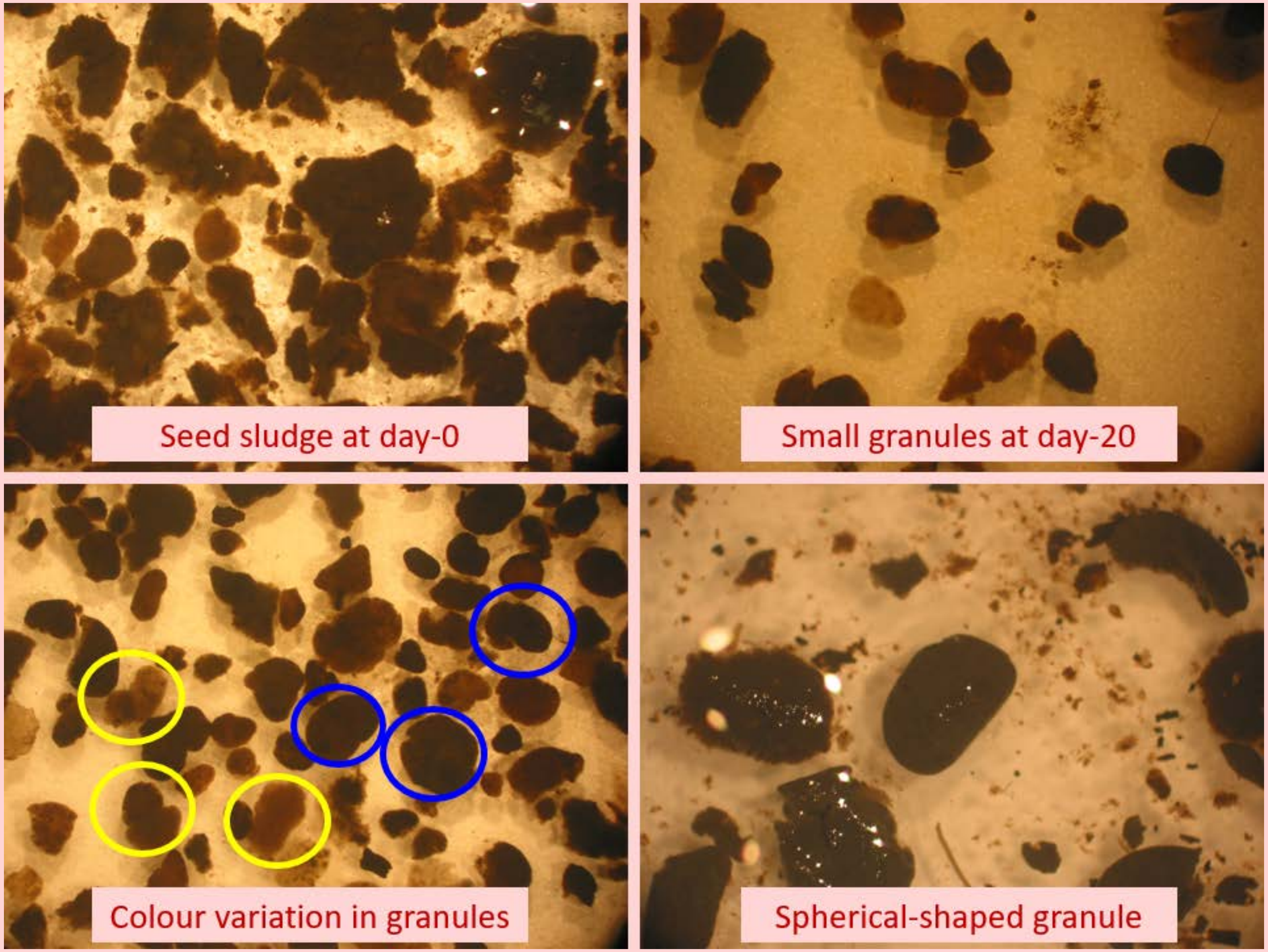
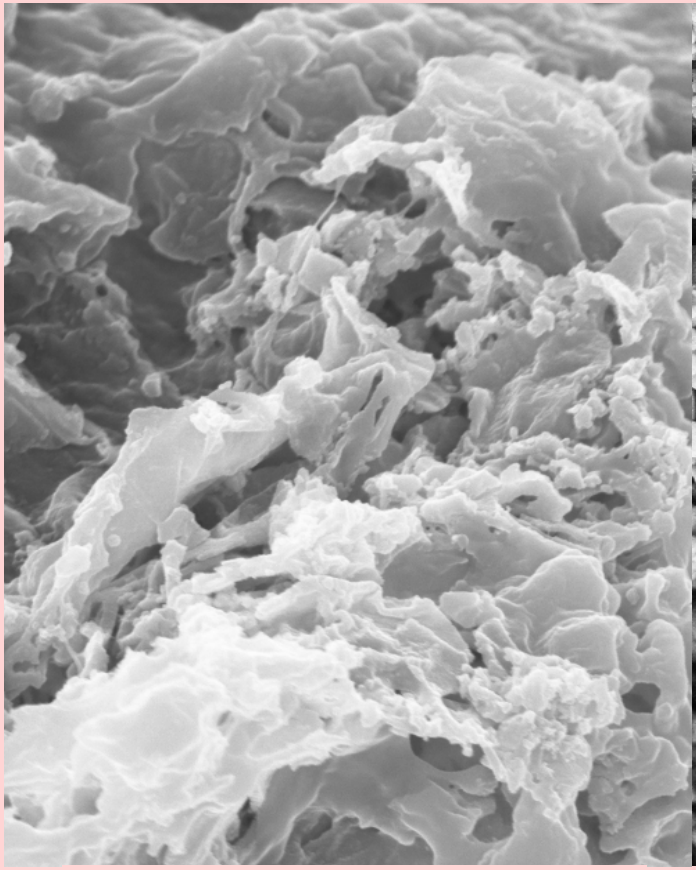
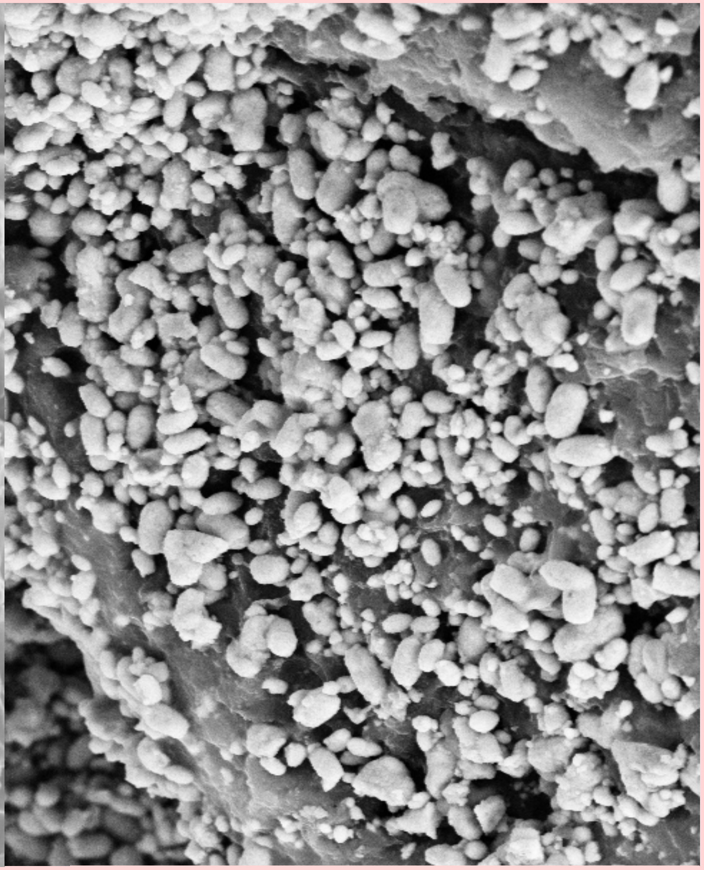
Formation of granules at 2.5 kgCOD $m^{-3}d^{-1}$



SEM analysis of seed sludge vs. mature aerobic granular sludge

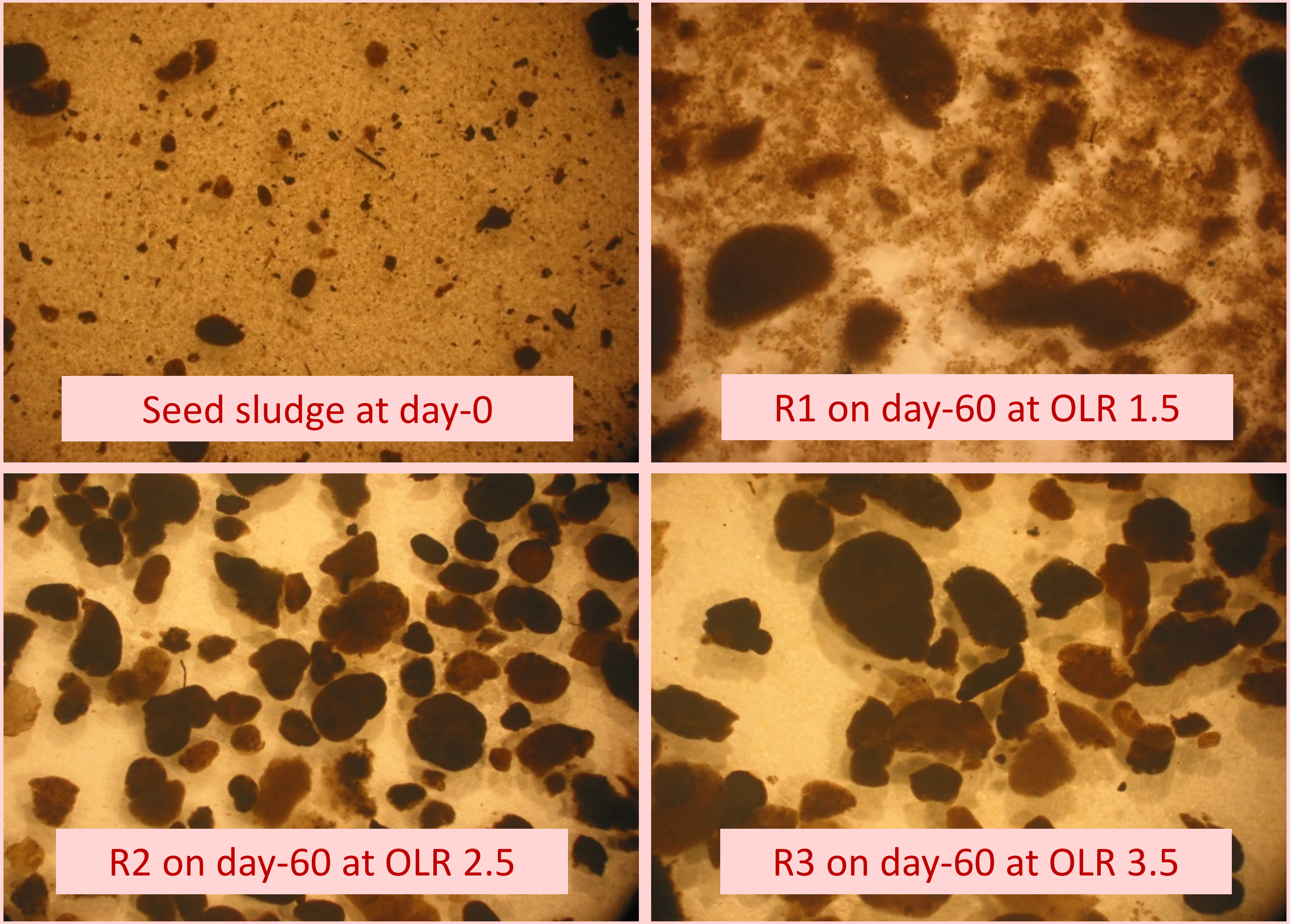


Seed sludge (Mag: 10,000x)

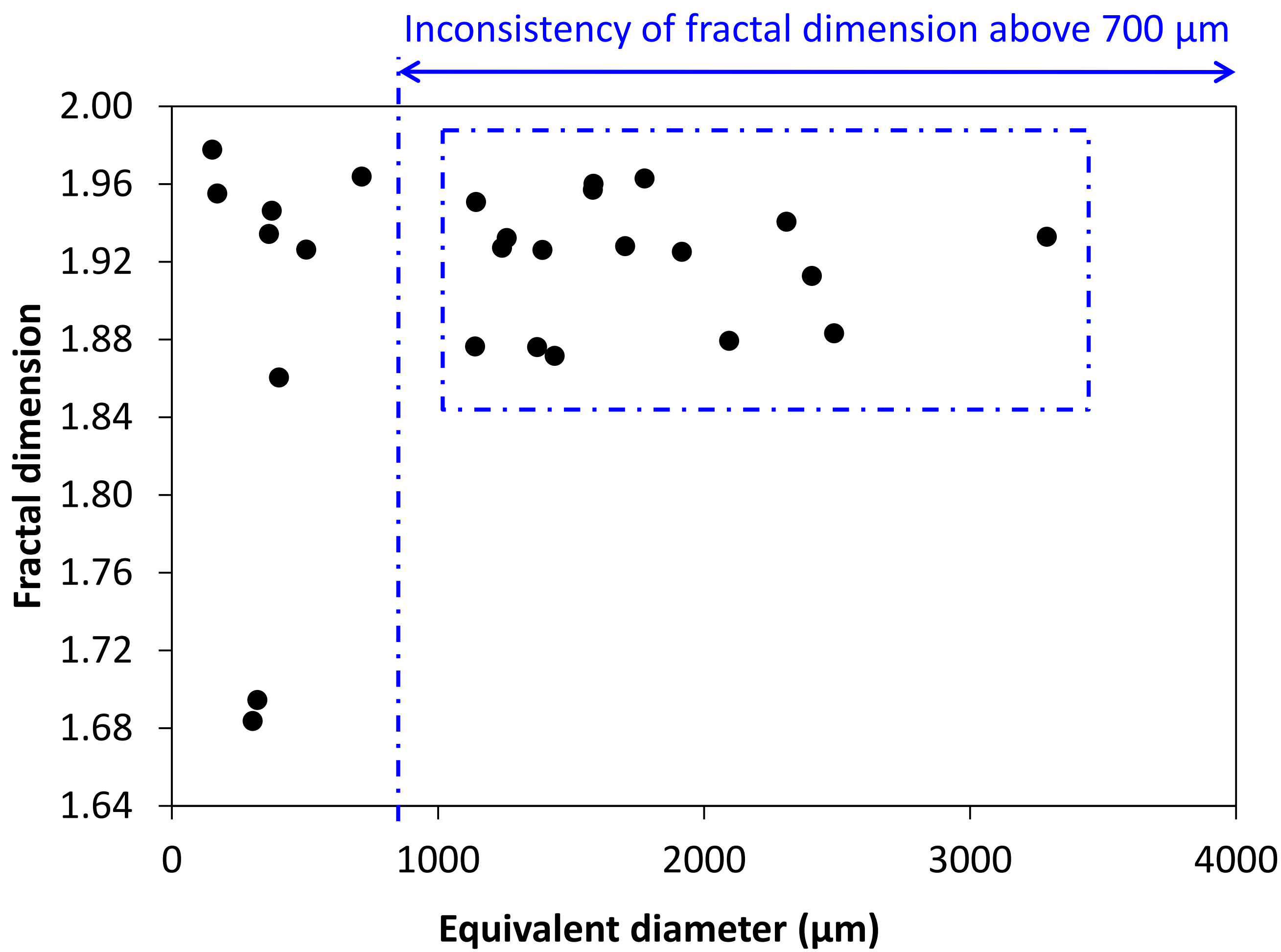


Mature granule (Mag: 5,000x)

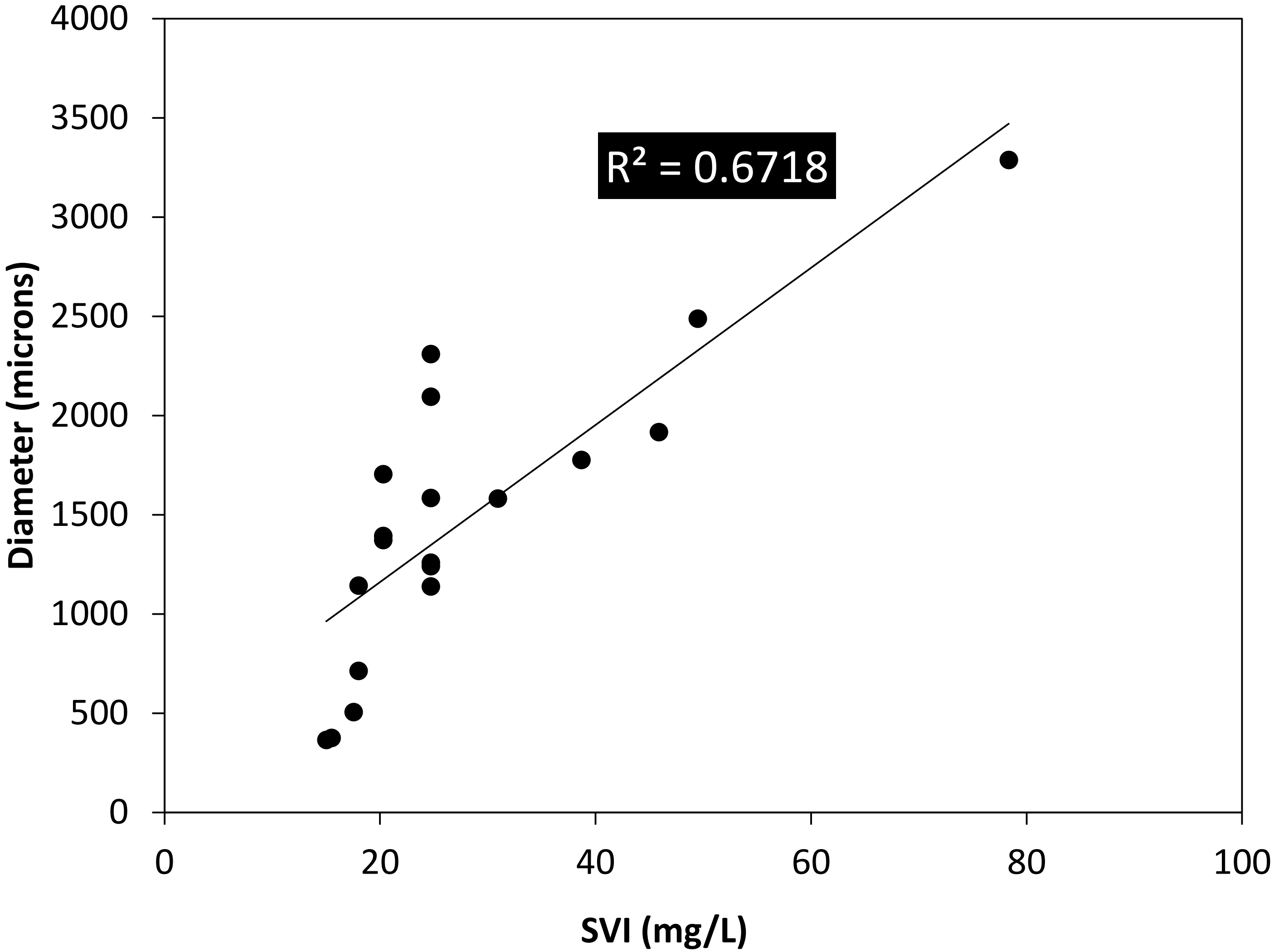
Mature granules at different OLR



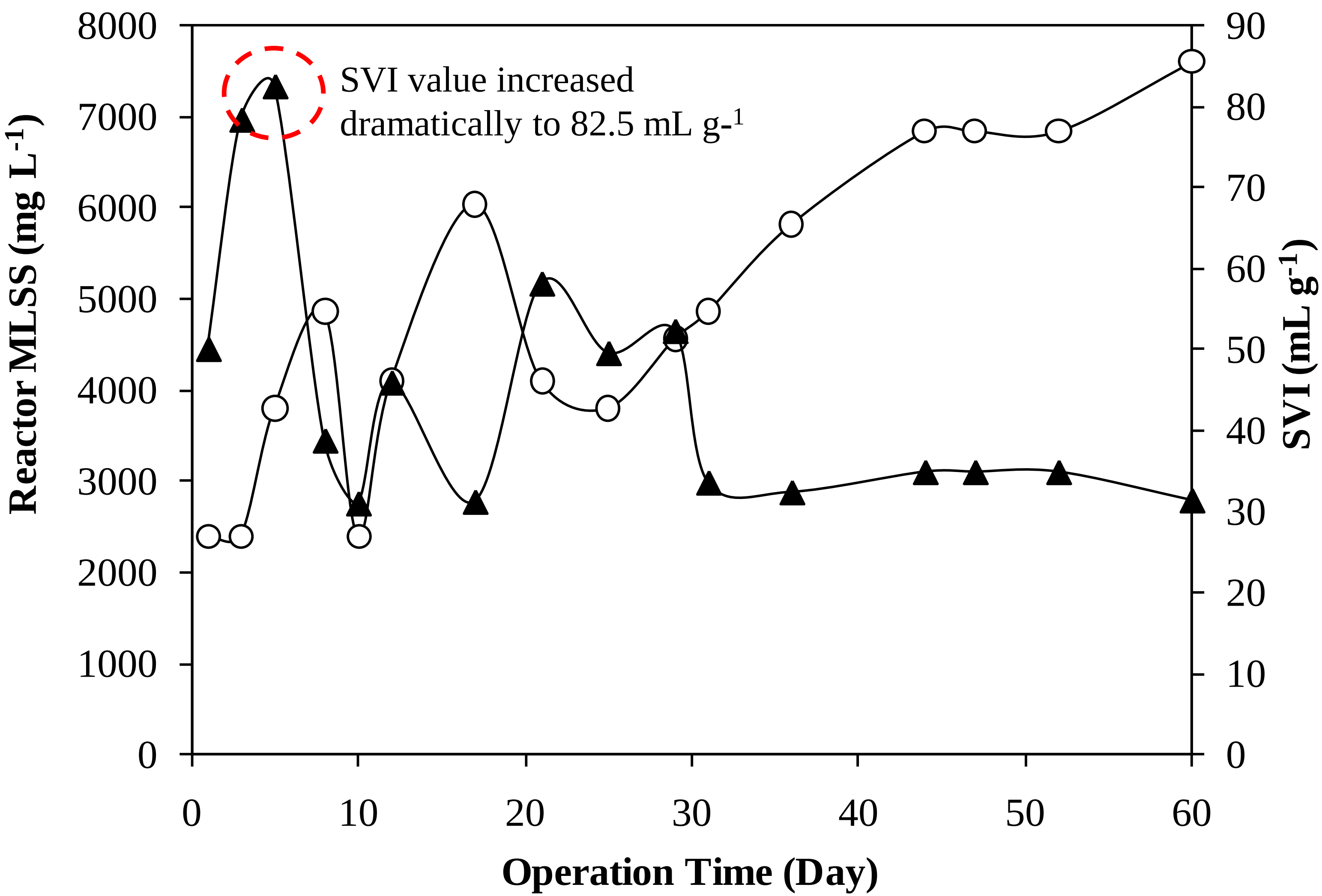
Physical and microbial characteristics of granule



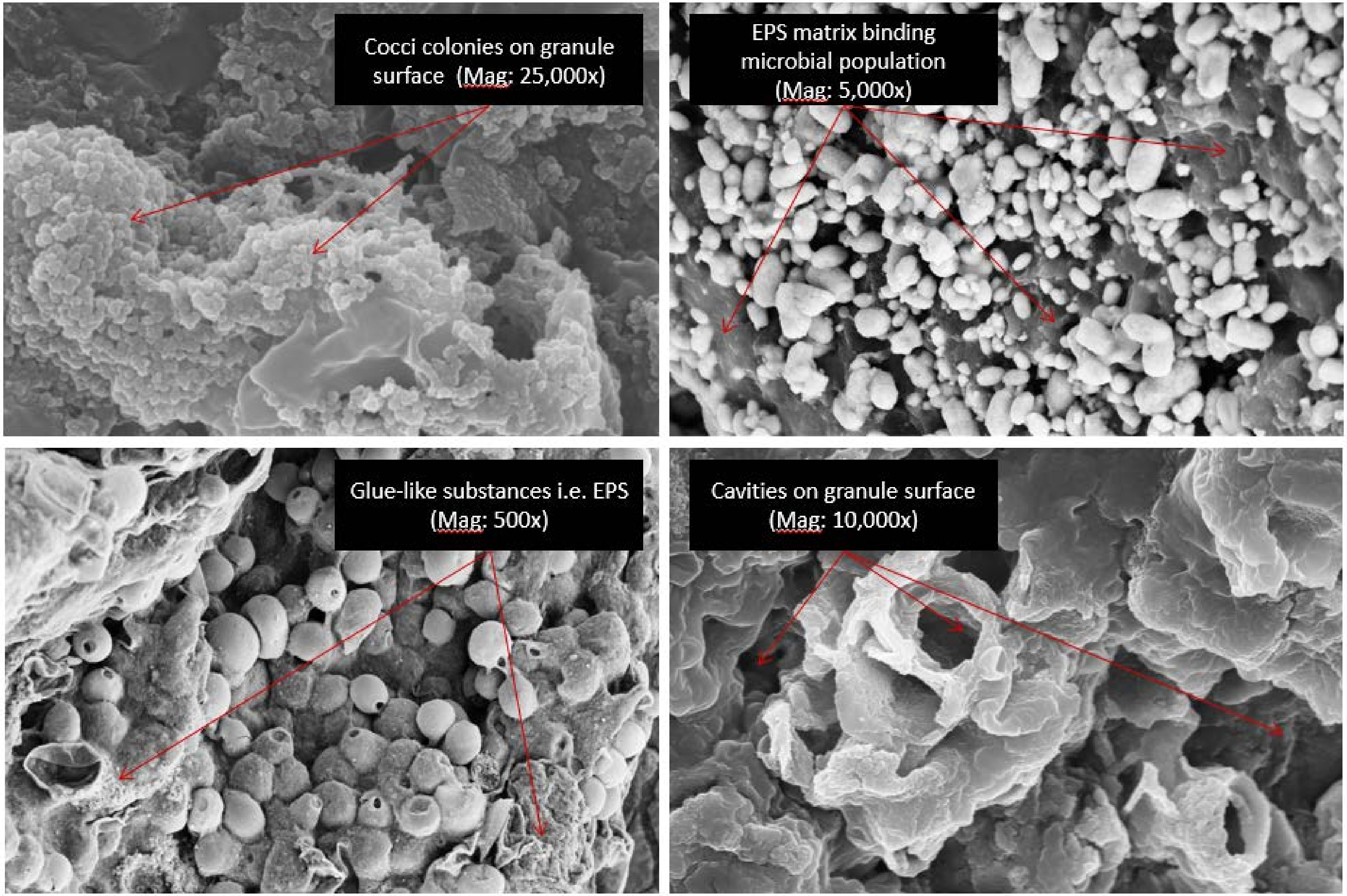
Fractal dimension vs. size profile for aerobic granular sludge indicating an almost linear relationship between fractal dimension and equivalent diameter of less than 700 µm



SVI vs size of aerobic granular sludge profile indicating good and positive association of two important parameters of granules



The trends of reactor MLSS concentration and SVI values of aerobic granules (○) MLSS concentration; (▲) SVI



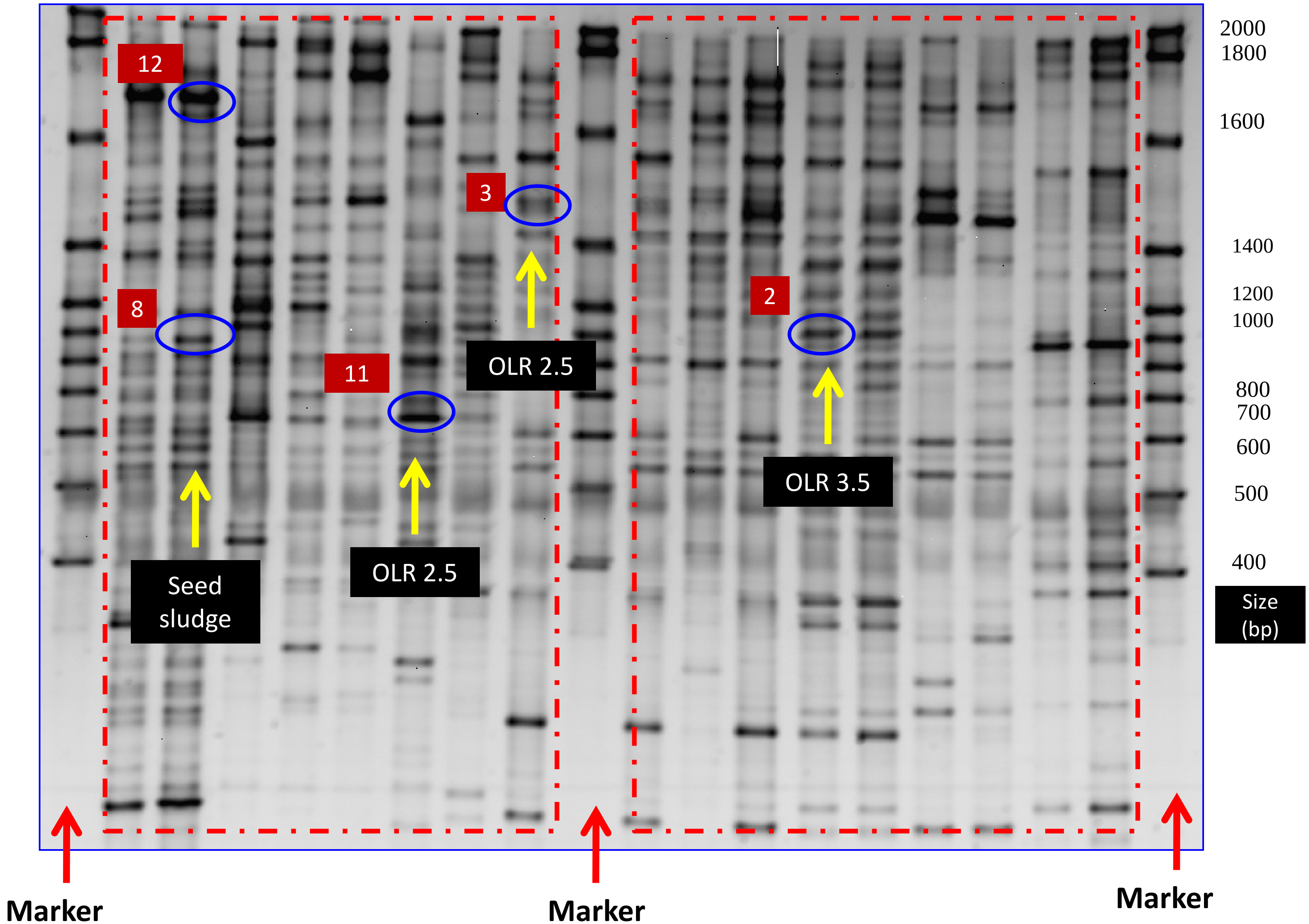
Micro-morphology of aerobic granular sludge explored using SEM

Diversity and evolutionary shift of bacterial population

Species identification of selected DGGE bands at different OLR

Bands	Closest relatives (accession no.)	Length (bp)	Identity (%)
1	*Kineosphaera limosa* (AB550802.1)	524	93
2	*Trichococcus* sp. 0 (FJ374769.1)	710	97
3	*Runella* sp. (GU223115.1)	1341	98
4	*Pseudomonas* sp. (HM051242.1)	799	95
5	Uncultured *Flavobacteriaceae* bacterium (EF651688.1)	510	97
6	Uncultured *Leadbetterella* sp. (GU560170.1)	1465	99
7	Uncultured bacterium (JF048329)	1341	96
8	Uncultured bacterium (JF048329)	546	96
9	Uncultured *Comamonadaceae* bacterium (HQ674824.1)	1494	98
10	Uncultured Bacterium (EU809170)	1274	91
11	Uncultured Bacterium (JF019340)	1354	100
12	Uncultured *Bacteroidetes* bacterium (FN669651.1)	1474	93
13	Uncultured *Propionibacteriaceae* bacterium (EU812987)	1499	100
14	Uncultured Bacterium (DQ906136)	590	97
15	Uncultured *Propionibacteriaceae* bacterium (EU812987.1)	1499	100
16	Uncultured Bacterium (GU562534)	808	95
17	Uncultured Bacterium (GU731738)	932	97
18	Uncultured *Methylobacillus* sp. (GQ390421.1)	1475	92
19	Uncultured Bacterium (GQ289449)	166	93

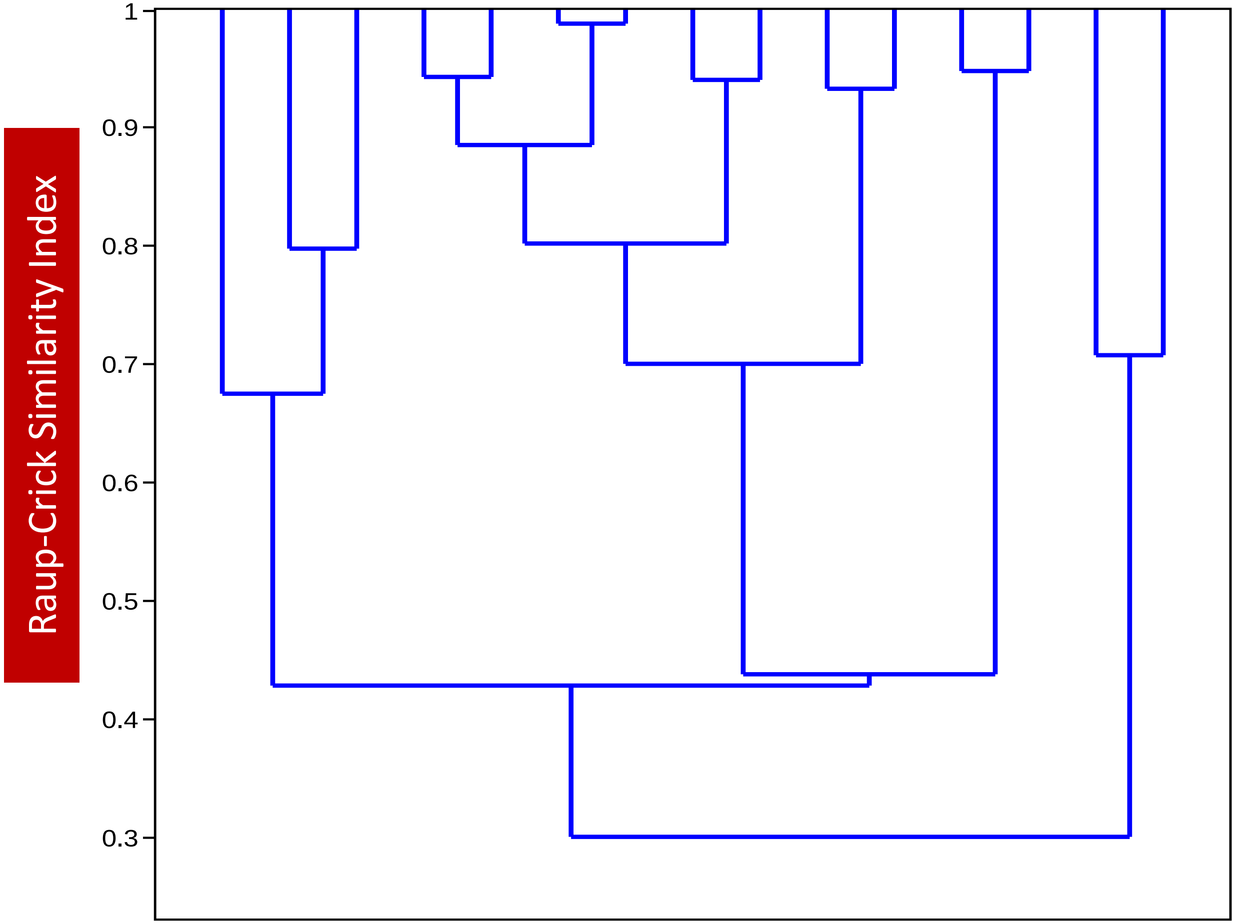
Example of selected bands from DGGE profiles of bacterial communities in SBRs



Species identification of AOB selected DGGE bands at different OLR

Bands	Closest relatives (accession no.)	Length (bp)	Identity (%)
1	Uncultured *Nitrosomonas* sp. (HQ184402)	419	98
2	*Thauera aminoaromatica* strain NS5 (FJ609701)	720	99
3	Ammonia-oxidizing bacterium NS500-9 (AY135356)	1392	100
4	Uncultured *Methylobacillus* sp. (GQ390421)	710	92
5	Ammonia-oxidizing bacterium NS500-9 (AY135356)	1516	100
6	Uncultured *Nitrosomonas* sp. (HQ184402)	1499	100
7	Uncultured *Nitrosomonas* sp. (GU073372)	446	97
8	*Nitrosomonas europaea* strain ATCC 25978 (GQ451713)	1392	100
9	Uncultured *Rhodocyclaceae* bacterium clone A26 (GU255493)	1460	100
10	*Nitrosomonas europaea* strain ATCC 25978 (GQ451713)	1499	100

Microbial population dynamics of aerobic granular sludge was converted into binary matrix corresponding to presence/absence data (species) using BioNumerics® Version 3.5 Applied Maths BVBA

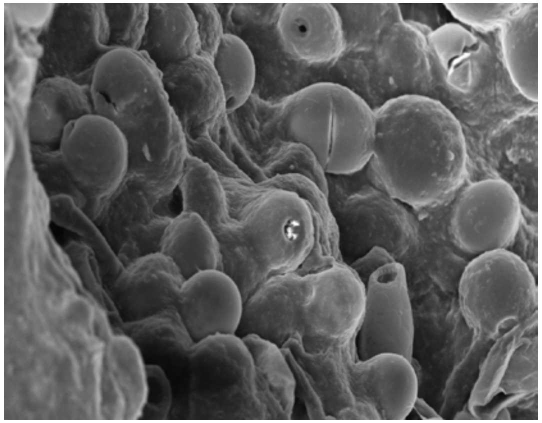


Dendrogram showing Raup-Crick similarity between microbial communities collected from the various state of aerobic granular sludge formation using POME

Dominancy of bacterial V3 region analysis

	Bacterial dominancy at different OLR[a]			
	Seed sludge	Mature granules at OLR 1.5	Mature granules at OLR 2.5	Mature granules at OLR 3.5
Uncultured *Bacteriodetes bacterium*	●	●	●	●
Kineosphaera limosa	●	○	○	●
Uncultured *Propionibacteriaceae* bacterium	●	○	○	●
Uncultured *Methyllobacillus*	○	●	●	●
Uncultured *Flavobacteriaceae* bacterium	●	●	●	●
Uncultured *Leadbetterella* sp.	●	●	●	○
Pseudomonas sp.	○	●	○	●
Runella sp.	○	○	●	●
Uncultured *Comamonadaceae* bacterium	○	●	●	●
Trichococcus sp.	○	○	○	●
Uncultured *Nitrosomonas* sp.	●	●	●	●
Thauera aminoaromatica	●	○	○	○
Nitrosomonas europaea	●	○	●	●
Uncultured *Rhodocyclaceae* bacterium	○	○	●	○

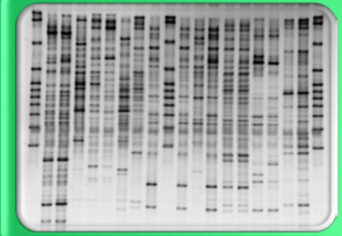
SEM of cocci-colonies possibly *Trichococcus* sp. found on mature granule (Mag: 1000x)



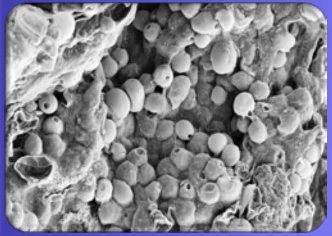
[a] OLR in kgCOD $m^{-3}d^{-1}$
○ indicates non-presence of bacteria
● indicates presence of bacteria in samples

CONCLUSIONS

Aerobic granular sludge was successfully developed at OLR 2.5 and 3.5 kgCOD $m^{-3}d^{-1}$



Physical and microbial characteristics of aerobic granular sludge developed using POME were successfully determined using fractal dimension analyses and molecular technique i.e. DGGE.



Significant bacterial shift was shown on DGGE banding profiles indicating microbial evolutionary shift on aerobic granular sludge. Bacterial properties, identities and functions of selected bacteria were defined at the end of this study.

Aerobic granulation technology has competitive potentials for applications in treating POME as well as other types of industrial wastewater based on efficient COD, ammonia and colour removal performances.

List of Publications

1.Hamzat Tijani, Ali Yuzir, Wan Rosmiza Zana Wan Dagang, Arash Zamyadi, Norhayati Abdullah (2018). Multi-parametric modelling and kinetic sensitivity of microalgal cells. Volume 32, Pages 259-269. (Q1)
2.Tijani, H., Abdullah, N. and Yuzir, A. (2018). Enhancing methane production of palm oil mill effluent using two-stage domesticated shear-loop anaerobic contact stabilization system. Journal of Cleaner Production. Volume 200, Pages 971-981. (Q1)
3.Tijani, H., Yuzir, A. and Abdullah, N. (2018). Producing desulfurized biogas using two-stage domesticated shear-loop anaerobic contact stabilization system. Waste Management. Volume 78, Pages 259-269. (Q1)
4.Yuzir, A., Sabri, A., Tijani, H., Abdullah, N., Syahrul, S. & Shreeshivadasan, C. (2017). Qualitative methods to identify potential strains for partial degradation of oil palm mesocarp fibre. Desalination and Water Treatment. 89, pages 280-286. (Q2)
5.Krishnan,Y., Phun Chien Bong, C., Azman, N.F., Zakaria, Z., Othman, N.A., Abdullah, N., Ho, C.S., Lee, C.T. , Hansen, S.B. (2017). Co-composting of palm empty fruit bunch and palm oil mill effluent: Microbial diversity and potential mitigation of greenhouse gas emission. *Journal of Cleaner Production.* Volume 146, Pages 94-100 (Impact Factor: 4.959) (Q1)
6.Abdullah, N., Fulazzaky, M.A., Yong, E.L., Yuzir, A., Sallis, P. (2016). Assessing the treatment of acetaminophen-contaminated brewery wastewater by an anaerobic packed-bed reactor. *Journal of Environmental Management.* Volume 168, Pages 273-279. (Impact Factor: 2.522) (Q3)

東京大学
THE UNIVERSITY OF TOKYO

Wastewater Treatment – Miscellaneous

RECWET Special Seminar Series #35
Research Center for Water Environment Technology
School of Engineering

Date 28 January 2019, Monday
Time 1015 – 1130
Venue Lecture Room #145 Engineering Building #14

Speaker Assoc Professor Dr Norhayati Abdullah
Guest Scholar
Graduate School of Advanced Integrated Studies in Human Survivability (Shishukan) Kyoto University, 201
L'Oreal-UNESCO For Women in Science Fellowship Award 2018
Fulbright US-ASEAN Visiting Scholar to University of Michigan, USA 2017