Microbial Processes in Aerobic Granules

Can we use them to treat wastewater more efficiently?

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Problem

Traditionally large activated sludge basins are used to treat wastewater. In this system:

- biomass is present as flocs
- large land space and a lot of energy are required

Thus, more efficient wastewater treatment systems are requested.

Proposed solution

A promising solution is aerobic granular sludge technology. Granules can be cultivated in sequencing batch bubble column reactors (SB-BCR) (Fig 1).

To get smooth and dense granules (Fig 2) the presence of slow growing organisms like phosphate accumulating organism (PAO) and glycogen accumulating organisms (GAO) is essential. Both microbes take up the C-source and transform it into poly-hydroxy-alkanoates (PHA). Contrarily to GAO, PAO can eliminate phosphate and are therefore preferred. PAO may also denitrify (DPAO) (Fig 3).

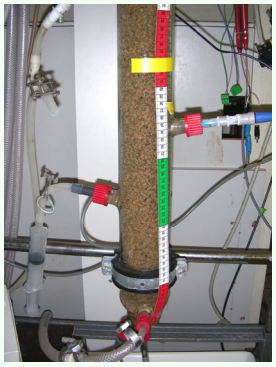


Fig 1. Picture of a SB-BCR with granules

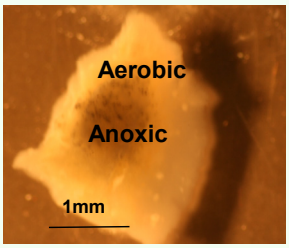


Fig 2. Cross-section of a granule. A granule is composed of diverse self-immobilized microorganisms

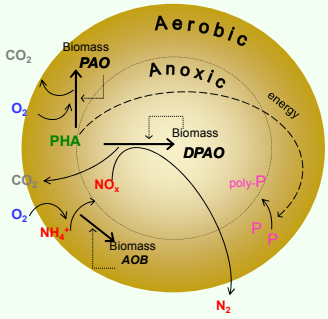


Fig 3. Microbial processes in granules

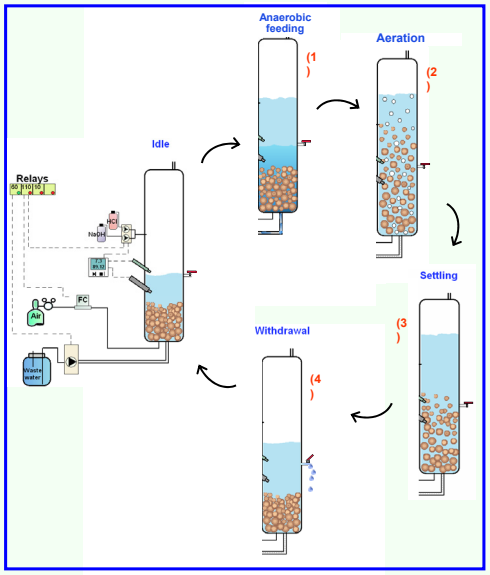
Advantages of aerobic granular compared to activated sludge

- C, N, P removal within one reactor
- land space and money savings due to good sludge settling characteristics
- less excess sludge production

How does the system work ?

The formation of granules takes place during a cycle with 4 different phases. It starts with an anaerobic phase (1) where the reactor is fed and substrate converted in poly-hydroxy-alkanoates (PHA) by PAO/GAO. Follows an aeration phase (2) where PHA are degraded for growth and phosphate is taken up by PAO. Then the aeration stops and the granules settle (3). And finally, the upper part, containing the cleaned water is withdrawn (4). Then the cycle starts again.

Run the reactor



Our investigation

We operated two bioreactors with synthetic wastewater, one with acetate and one with propionate. Propionate feeding is suspected to favor PAO growth. Moreover, it could become interesting for cultivation of a newly discovered anammox bacterium using propionate, which would enhance N removal.

Fig 5. Granular sludge stained by FISH to show PAO

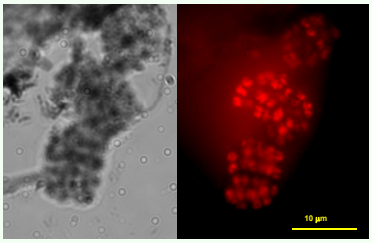
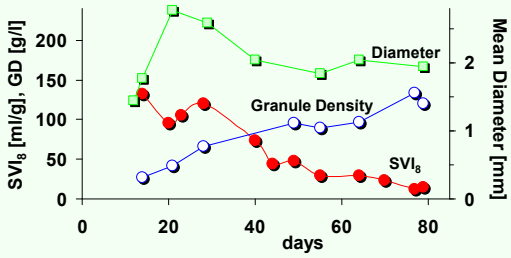


Fig 4. Granules physical characteristics



Our results

- stable, fast settling granules were obtained (low SVI_8; Fig 4)
- big amount of PAO in biomass (Fig 5)
- chemical profiles during a cycle operation showed typical PAO metabolism (Fig 6)
- complete C-, high P- and moderate N-removal (Fig 7)

Fig 6. Cycle monitoring (propionate): day 71

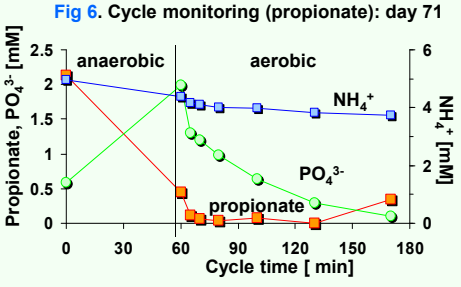
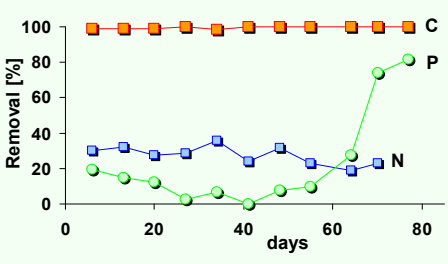


Fig 7. Reactor performance (propionate)



Conclusions

- It was possible to get granules with propionate as substrate
- biological dephosphatation by PAO was achieved but no nitrogen removal
- further investigations will concentrate on inclusion of nitrifiers in the granules

Acknowledgements

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