MaB-flocs for a more sustainable wastewater treatment

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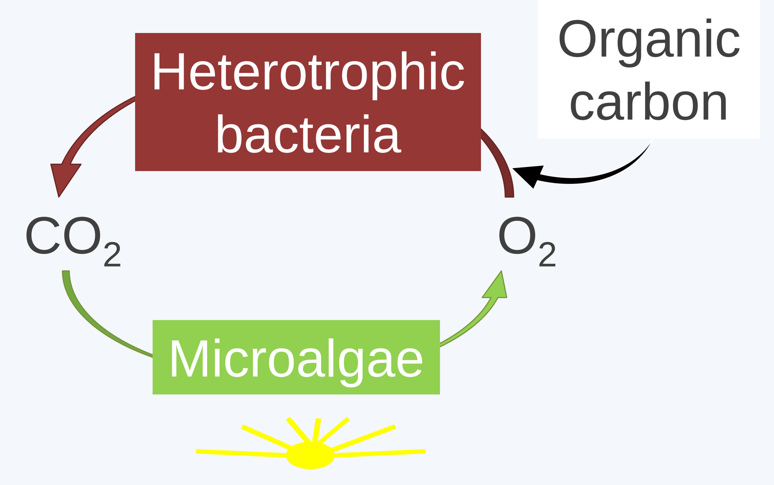
Lowering the carbon footprint of wastewater treatment

Conventional activated sludge system
High aeration rates and CO_2 emission by bacteria

Microalgal Bacterial (MaB) floc system
O_2 produced *in situ* and CO_2 captured in biomass



Microalgae do not settle easily
High cost of harvesting

MaB-flocs settle by gravity
Bioflocculation of microalgae and activated sludge

Objective

To maximize the photosynthetic aeration and CO_2 mitigation of MaB-floc reactors for wastewater treatment, we investigated whether inorganic carbon could increase the algae:bacteria ratio in the flocs while keeping a good reactor performance and biomass separation.

Methods

Experiments were conducted in three illuminated sequencing batch reactors (SBR) with MaB-flocs fed with synthetic wastewater containing inorganic carbon compared to organic carbon (Table 1).

The reactors were operated in 2 cycles of 5 hours and one cycle of 14 hours per day (Fig. 1). No external oxygen was supplied. This experiment was performed in duplicate experiments.

Table 1. Influent carbon composition

Reactor	C-bicarbonate (mg C L^{-1})	C-sucrose (mg C L^{-1})
SBR-B	84	0
SBR-BS	42	42
SBR-S	0	84

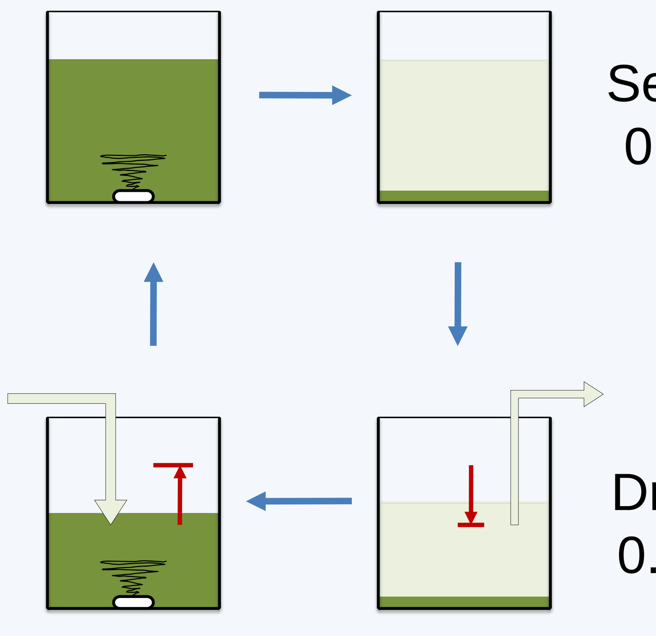
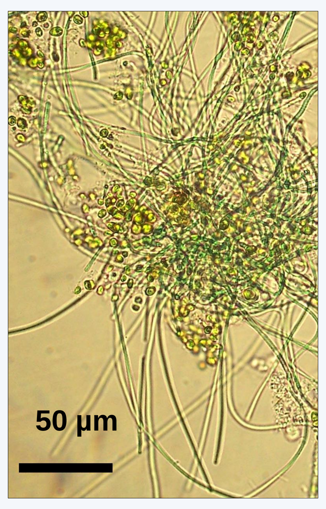


Figure 1. SBR cycle of MaB-floc reactors

Results

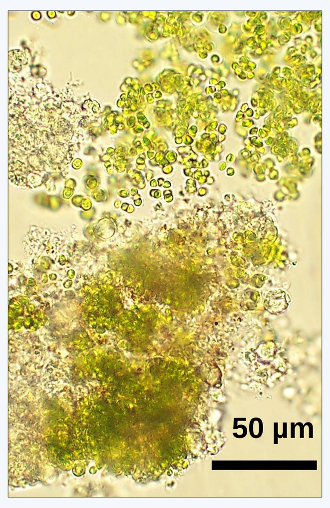
Several differences were found in MaB-floc reactors fed with bicarbonate compared to sucrose.



MaB-floc SBR-B

Bicarbonate

- More chlorophyll *a* in flocs (Fig .2)
- Lower floc settleability
- Increasing pH: up to 9.5
- More filamentous cyanobacteria
- Higher effluent turbidity
- Lower N removal (Table 2)



MaB-floc SBR-S

Sucrose

- Good floc settleability
- Neutral pH: around 7
- Lower dissolved oxygen but good soluble COD removal
- Lower effluent turbidity
- Good N removal (Table 2)

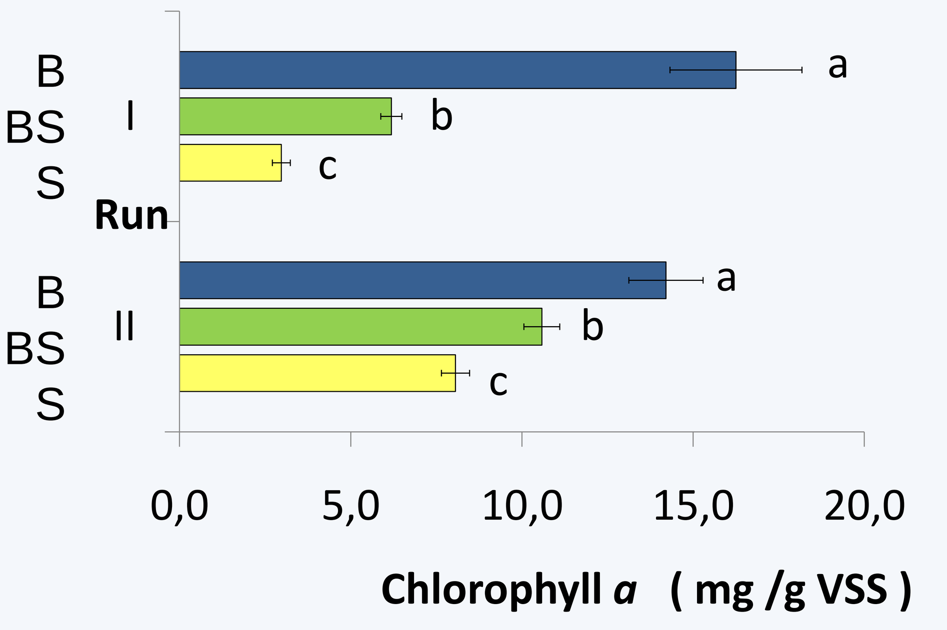


Figure 2. Chlorophyll a content of MaB-flocs fed with bicarbonate (B) and/or sucrose (S) in two experimental runs

Table 2. Process performance of SBRs with MaB-flocs fed with bicarbonate (B) and/or sucrose (S) in two experimental runs (mean +- standard deviation (measurements))

Run	Reactor	Daily removal (mg L^{-1} reactor day^{-1})		Removal efficiency (%)		Turbidity (FTU)
		SCOD*	$N\text{-}NO_3$**	SCOD*	$N\text{-}NO_3$**	
I	SBR-B	-	3.3 ± 2.2 (4) ^{g}	-	11.1 ± 7.4 (4) ^{g}	8.6 ± 3.4 (9) ^{g}
	SBR-BS	154 ± 5 (8) ^{e}	15.6 ± 4.3 (8) ^{h}	92 ± 3 (8) ^{a}	52.2 ± 14.4 (8) ^{h}	1.5 ± 1.2 (9) ^{h}
	SBR-S	318 ± 6 (8) ^{f}	20.4 ± 5.0 (8) ^{i}	95 ± 2 (8) ^{b}	68.2 ± 16.7 (8) ^{i}	2.3 ± 1.6 (9) ^{i}
II	SBR-B	-	5.8 ± 2.6 (5) ^{g}	-	19.7 ± 10.1 (5) ^{g}	10.9 ± 4.8 (7) ^{g}
	SBR-BS	158 ± 7 (7) ^{e}	11.3 ± 1.6 (9) ^{h}	94 ± 4 (7) ^{a}	37.9 ± 5.2 (9) ^{h}	1.7 ± 1.2 (7) ^{h}
	SBR-S	320 ± 7 (7) ^{f}	18.4 ± 6.8 (9) ^{i}	96 ± 2 (7) ^{a}	61.4 ± 22.6 (9) ^{i}	3.5 ± 2.2 (7) ^{i}

* Soluble COD; shown where relevant, i.e. where organic carbon was fed to the reactor   ** Only N-removal analyses before reactor washout were used

Conclusions

- Inorganic carbon increases the photosynthetic micro-organisms content and potential of MaB-flocs.
- Organic carbon is of major importance for a good reactor performance, i.e. floc settleability and N-removal.
- Photosynthetic oxygenation of COD (and thus CO_2 incorporation in algal biomass) is feasible.

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