Evaluation of effect of different nitrogen sources on oxygen productivity and nutrient metabolism of *Arthrospira* sp. PCC 8005 in a continuous photobioreactor

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INTRODUCTION

The ability of autotrophic cyanobacteria *Arthrospira* sp. PCC 8005, to thrive and grow using waste nitrogen (both organic and inorganic) and release oxygen has made it a potential candidate for the production of oxygen for astronauts in the MELISA loop. The present case study evaluated the growth profile, biomass productivity and oxygen productivity of *Arthrospira* sp. PCC 8005 in a photobioreactor (PBR) operated under turbiostat conditions. Four transitions between nitrate (NO_3^-) and Ammonium (NH_4^+) as the nitrogen (N); were made over a period of 100 days.

Results & Discussions

Growth Profile

Optical density (OD_{750nm}) was used to compute the growth profile of cyanobacteria (Fig.1). Comparatively higher OD_{750nm} was observed under NO_3^- regime (vs NH_4^+) potentially due to the higher assimilation rate of NH_4^+ that led to earlier onset of N deplete conditions. The OD_{750nm} was found to decrease within the initial few days of transition but recovered thereafter indicating acclimatization to the new N regime.

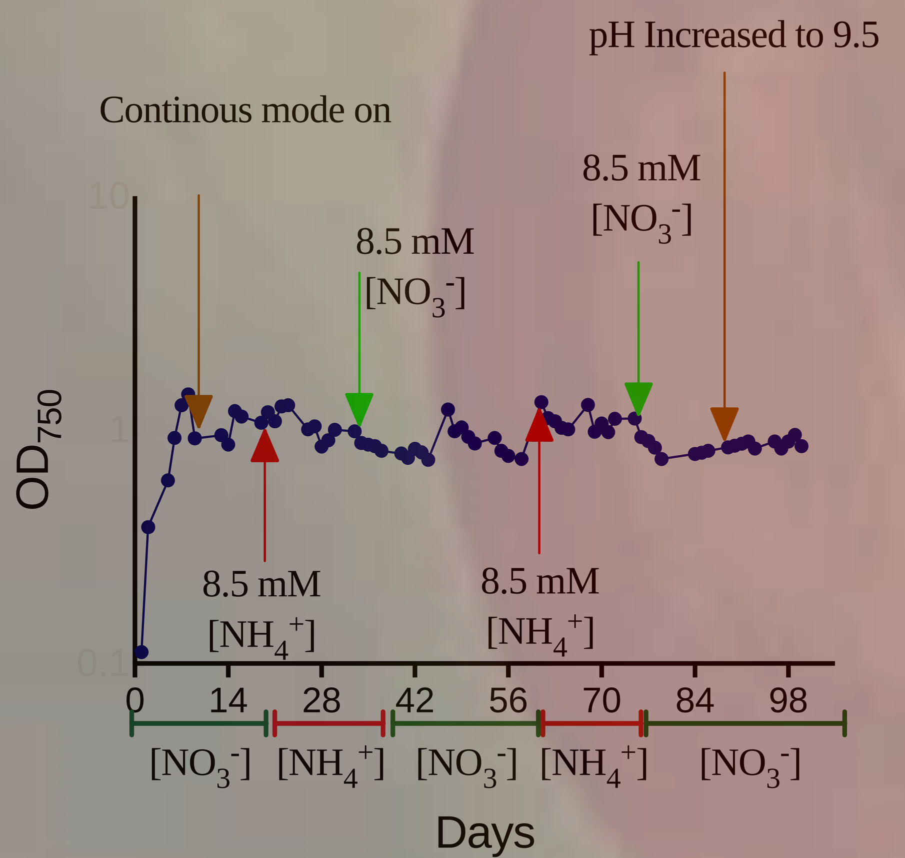

Fig.1 Effect of nutrient transition (NO_3^- to NH_4^+) on the growth (OD_{750nm}) of *Arthropsira* sp. PCC 8005 under turbidostat mode of continuous PBR.

Effect of nitrogen source on biomass & oxygen productivity

Higher biomass and oxygen (O_2) productivity (Fig.2) were observed under NO_3^- (vs NH_4^+) regime. The 75% lower O_2 yield under NH_4^+ regime could be attributed to the difference in the chemistry of NH_4^+ and NO_3^- ions (expected 83% based on stoichiometry). The average O_2 yields, O_2 productivity and biomass productivity were consistently found to higher under NO_3^- (vs NH_4^+) regimes (Table 1).

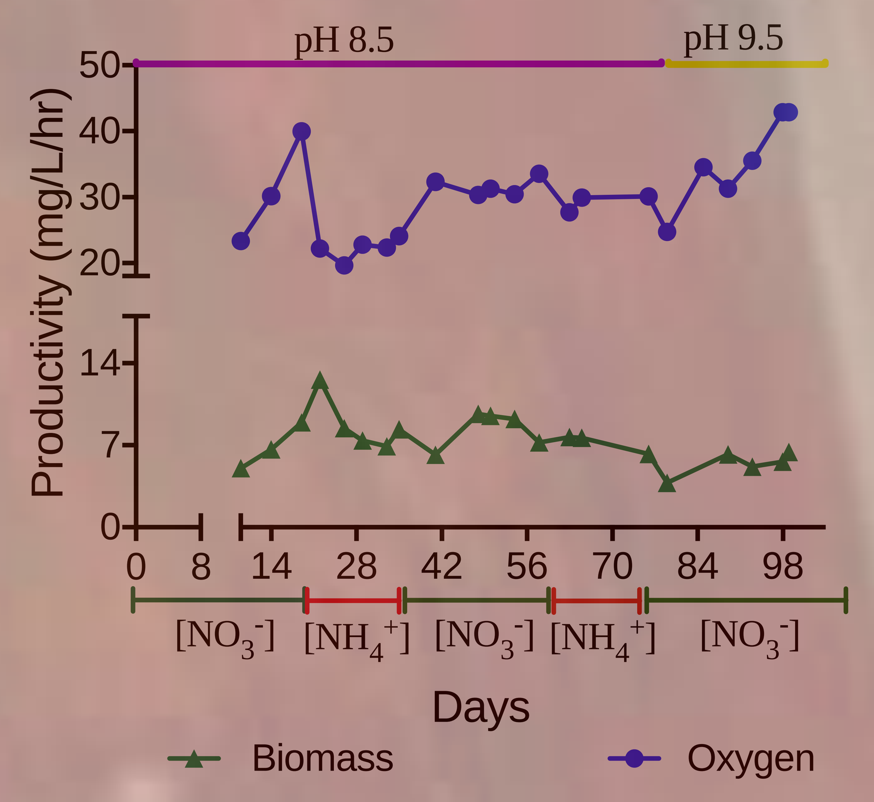

Fig.2 Effect of nutrient transition (NO_3^- to NH_4^+), on biomass and oxygen productivity of *Arthropsira* sp. PCC 8005 under turbidostat mode of continuous PBR.

Table 1: Effect of nitrogen regime, pH variation and light intensity on oxygen yield, biomass and oxygen productivity of *Arthrospira* sp. PCC 8005.

Days	N Regime	Average Biomass Productivity (mg/L/hr)	Average Oxygen Productivity (mg/L/hr)	Average Oxygen Yield
9-19	NO_3^-	8.27	35.96	0.36
20-35	NH_4^+	7.75	23.54	0.26
36-61	NO_3^-	8.31	29.04	0.31
62-75	NH_4^+	6.61	28.02	0.23
76-100*	NO_3^-	5.51	32.55	0.29

* Variations in light intensity and pH were made in this transition (details Fig.1)

Nitrogen Utilization Profile

Minimal to no accumulation of NO_3^- and NH_4^+ (Fig.3) were observed in PBR, further indicating at nutrient starvation conditions at 8.5mM (total N) concentration. This was also evident from negligible cyanophycin levels (endogenous N storage compound) in the cells throughout the run (data not shown) under both N regimes. Exogenous nitrite and urea (Fig. 4) were quantified in the samples when the cyanobacteria were fed with NO_3^- which is consistent with our previous studies under both batch and continuous mode irrespective of NO_3^- concentration. The prevalence of nutrient deplete conditions at 8.5 mM (total N) was also evident from high total C:N ratio (Fig.5) in the outlet (biomass and supernatant) which rose upto 400 (compared to an average of 4)[1] for cyanobacteria under normal conditions. This skewed ratio was a direct result of very low N levels.

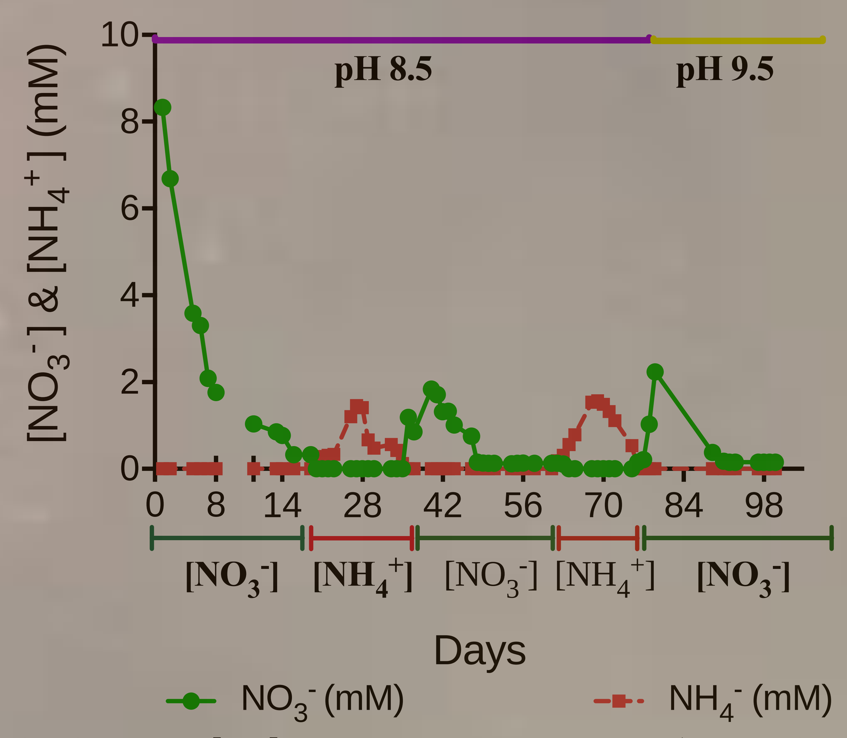

Fig.3 Residual N concentrations (NO_3^- and NH_4^+) for *Arthropsira* sp. PCC 8005 cultivated in continuous PBR with a feeding N concentration of 8.5 mM.

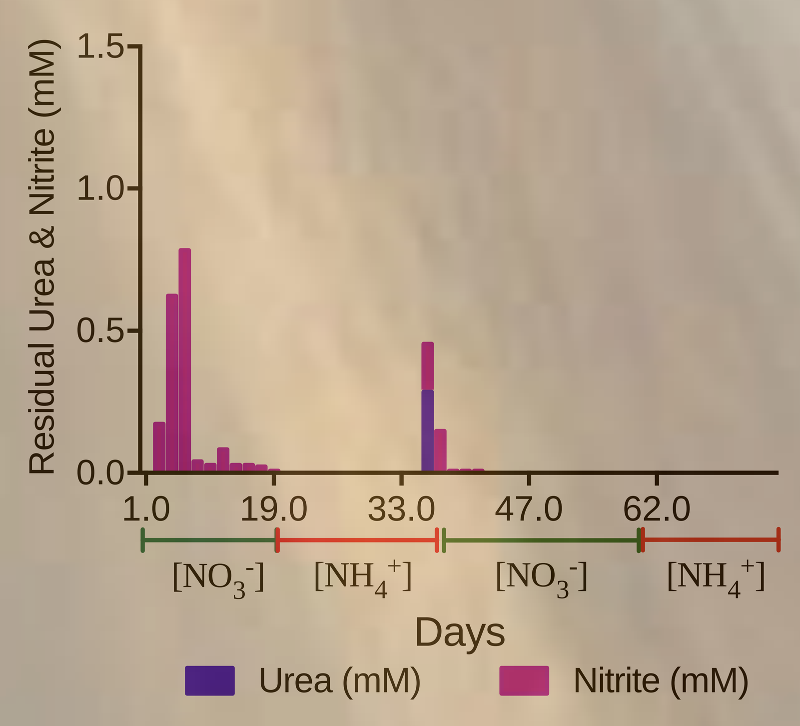

Fig.4 Residual N concentrations (as nitrite and urea) for *Arthrospira* sp. PCC 8005 cultivated in continuous PBR with a feeding N concentration of 8.5 mM (NO_3^- / NH_4^+)

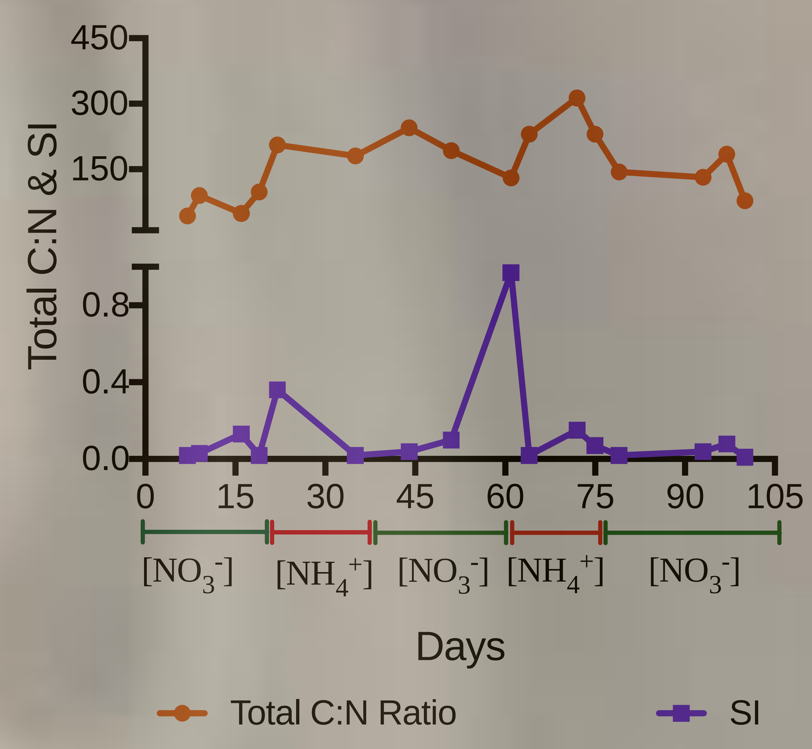

Fig.5 Effect of variation of N source, pH and light on Total C:N (outlet) and SI for *Arthrospira* sp. PCC 8005, cultivated in continuous PBR.

CONCLUSIONS

- NH_4^+ could be used for cultivation of cyanobacteria (N concentration 8.5 mM, pH 8.5) to obtain comparable biomass and oxygen productivities without cellular toxicity/ inhibition[2].
- Since N limiting conditions was observed at 8.5 mM (total N concentration), the feeding N concentration could be increased without risk of inhibitory effect of NH_4^+[2].
- Potential to increase the oxygen and biomass productivity (under the above working conditions) by working under higher light intensity (than 140 µmol photons/m²/sec) without potential photoinhibition/ phototoxicity effect[3].
- Even if not optimal, productivity is only slightly lower at pH 8.5 in comparison with results obtained at pH 9.5.

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