CHARACTERIZATION OF MICROALGAE-BACTERIA BIOMASS IN PHOTOBIOREACTOR FOR WASTEWATER TREATMENT

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INTRODUCTION

- The symbiotic co-culture of microalgae and activated sludge with CO_2-O_2 closed cycle has been taken a lot of advantages, such as no need for aeration, ability to treat various kinds of wastewater and high microalgae recovery efficiency. The aggregation of co-culture biomass were developed through both non-flocculation and bioflocculation processes**,** and the **mixing conditions being one of the key factors** for controlling the performance of these processes.
- By applying **microalgae-activated sludge co-culture** system in PBR, operating in sequencing batch mode at different agitation speed in order to investigate the **optimal stirring condition** of PBR in terms of characterization flocculation process, and wastewater treatment performance

OBJECTIVES

- To form fully developed microalgae-bacteria granules.
- To find the optimal shear stress value for flocculation-granulation process and wastewater treatment performance

MATERIALS AND METHODS

1. Microalgae strains and activated sludge

- *Chlorella vulgaris* strain was cultivated in BBM for 18 days to obtain the *targeted biomass concentration of 1 g/L.*
- The aerobic activated sludge obtained from ASP process. *The initial seed sludge concentration was 3 g/L.*

2. Experimental set-up of PBR system

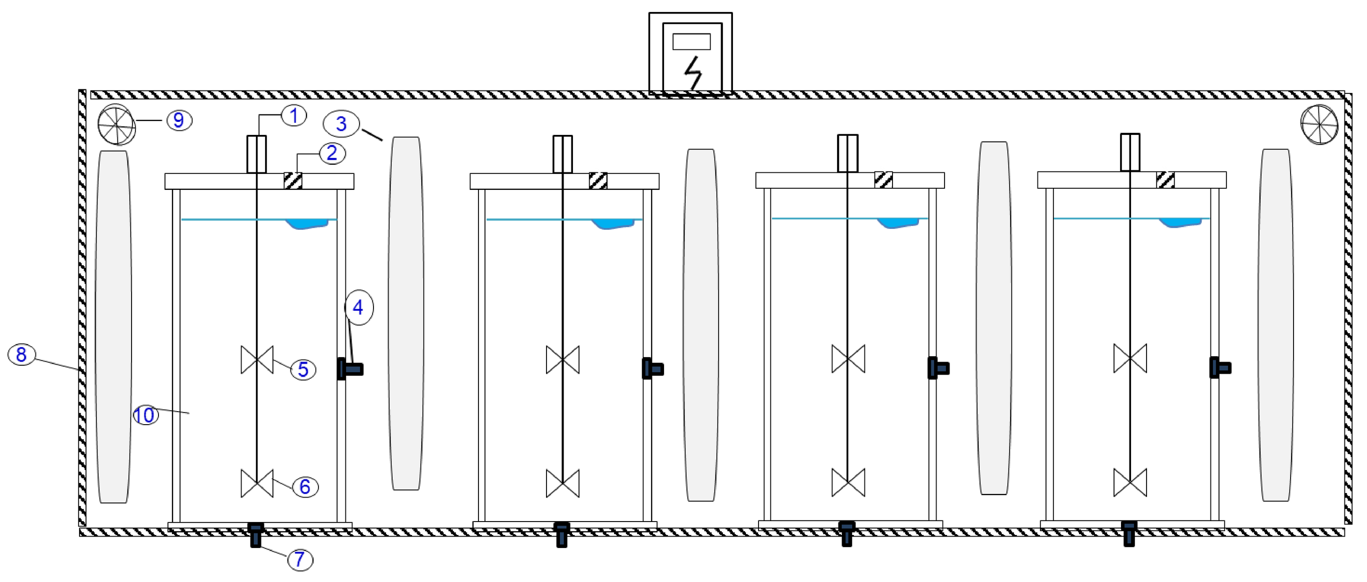


Diagram of PBR system for co-culture flocculation process

1. Agitator, 2. Feeding port, 3. Lights, 4. Effluent valve, 5.1st propeller, 6. 2nd propeller, 7. Discharge valve, 8. Wooden box, 9. Ventilation fan, 10. Photobioreactor

3. Operating condition

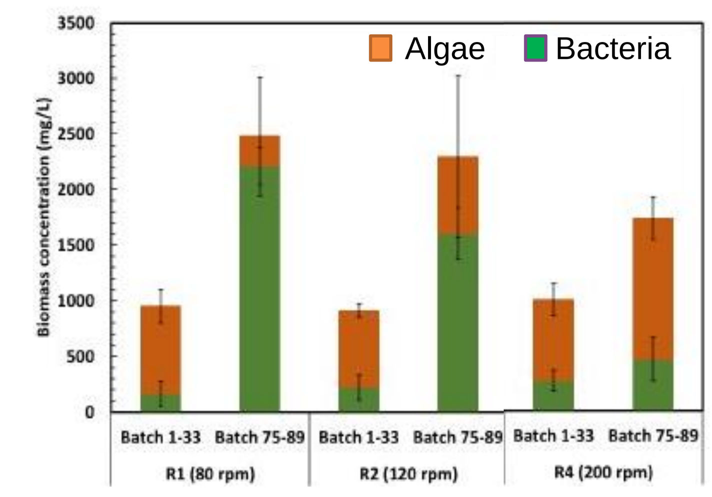
Operating parameters	Agitation speed (rpm)		
	200	120	80
Inoculation (Microalgae: Activated sludge)	5:1 (wt/wt)		
Initial concentration	600 mg/L		
Light intensity (lux)	4000		
Light/dark cycle (hour)	12:12		
Volumetric exchange ratio (%)	50		

- **Synthetic wastewater** including: COD= 384 ± 20 mg L^{-1} , TN as ammonium (NH_4^+)= 40 mg L^{-1}, TP= 4 mg L^{-1}, nitrate and nitrite were not detected.
- The **C:N:P mass ratio is about 100:10:1**

Phase	Time		
	Phase I	Phase II	Phase III
	day 1 – day 20	day 20 – day 62	day 63 – day 89
Influent adding	15 min		
Reaction	24h		
Settling	6h	3h	30 min
Discharge effluent	15 min settled biomass was continue to use for next batch.		

RESULTS AND DISCUSSION

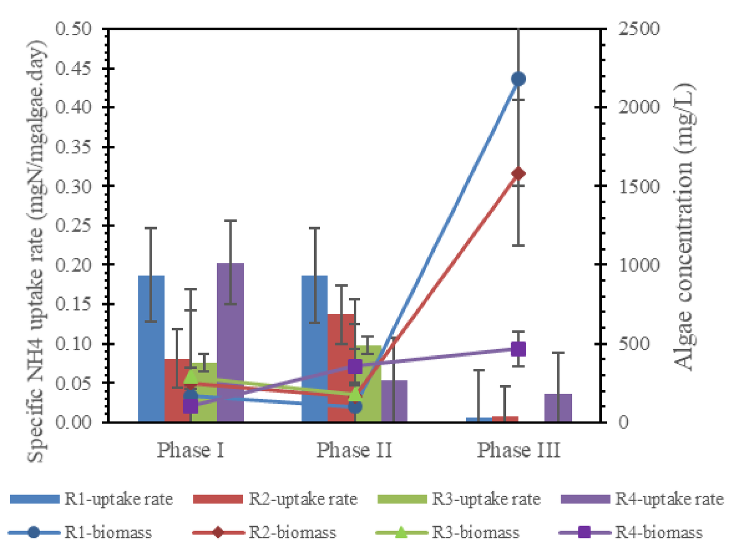
1. Biomass growth



- **Highest total biomass** concentration was **2478 mg/L (R1)**
- Microalgae – Bacteria ratio was **8.35** (R1 - phase III)
- **Highest total biomass productivity** reached **22.66 mg/L.d** (R1)
- **Lowest total biomass productivity** was **10.94 mg/L.d** (R3)

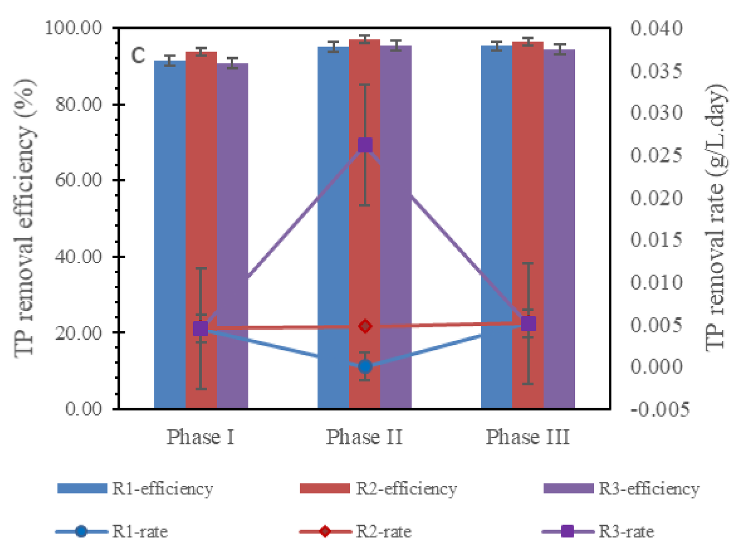
→ Low agitation speed stimulate microalgae growth & biomass growth

2. Removal performance



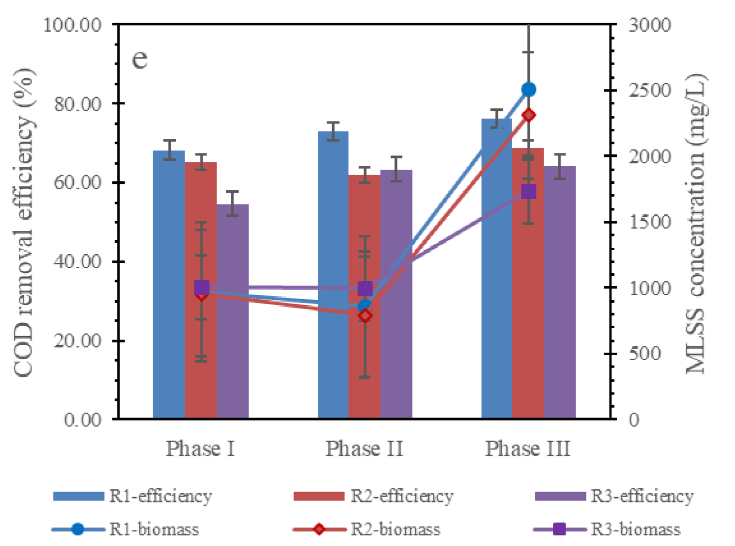
- **Nitrogen removal** was assessed by the reduction of NH4-N concentration via **algae biomass assimilation.**
- **Decrease** of uptake rate corresponding to **increase** of biomass concentration
- Similar **NH4-N removal efficiency (~ 28%)** of three reactors.

→ Low light penetration by tangled, dense biomass preventing photosynthesis and algal activity



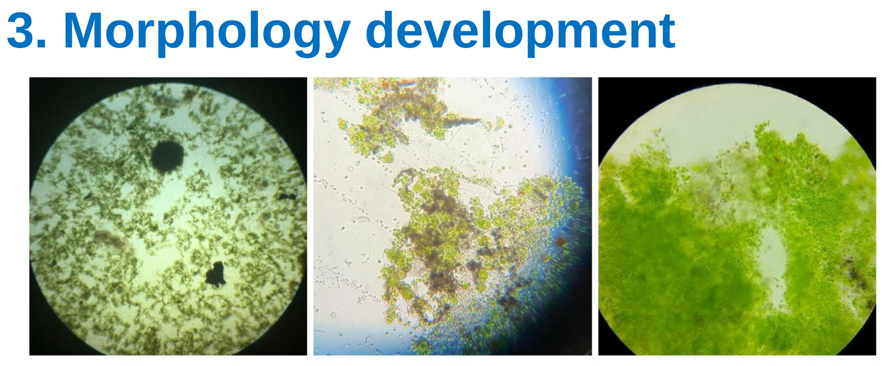
- **TP removal** performances stayed **stable** with high efficiency **(90% - 97%)**
- Phosphorous is primarily removed via **biomass uptake** by phosphorus accumulating organisms (PAOs) *(Zhu et al., 2019)*.

→ Agitation speed did not seem to significantly influence on nutrient removal

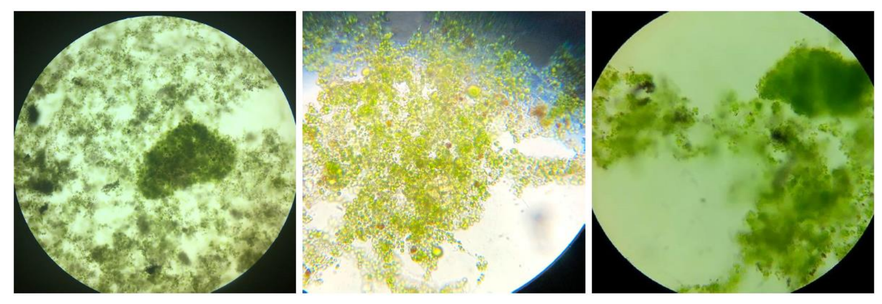


- Even the **biomass of bacteria was decreased,** but **COD removal efficiency** still increase according to the increase of microalgae biomass**,** due to the presence of mixotrophic algae use organic matter as carbon source *(Mutjaba and Lee, 2017)*.
- **Highest** COD removal efficiency (> 70%) & removal rate (307.0 ± 51.1 mg/L.d) in **R1**

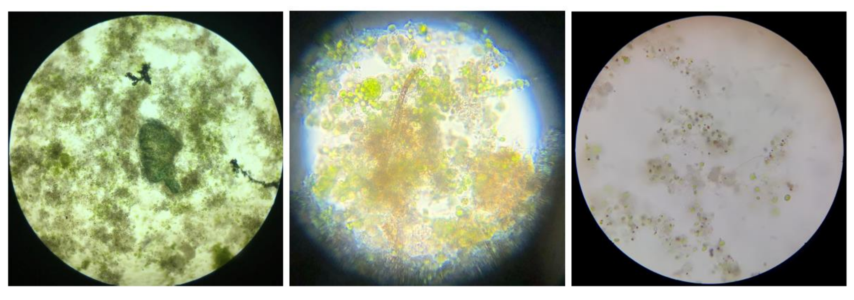
3. Morphology development



Microscope observation in R1 14th, 53th and 83th day (x40)



Microscope observation in R2 14th, 53th and 83th day (x40)



Microscope observation in R3 14th, 53th and 83th day (x40)

→**Agitation speed appeared to have an impact on biomass characteristic**

CONCLUSIONS

✓ Low agitation speed in R80 showed the most significant microalgal growth rate, dense flocs and the most effective average COD removal up to 76.1%, TP removal efficiency at 98.5% although NH_4 removal only reached 46.1% among 3 reactors. In contrast, high agitation speed of R200 created a suitable environment for bacterial growth and smaller flocs.

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