Substrate and Biomass: An Assessment of Specific Monitoring Tools for Drinking Water Biofiltration

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INTRODUCTION

Amino acid amendments, as easily biodegradable organic matter, have great potential for improving the biological acvity of biomass in biofilters.

In this study, photoelectrochemical oxygen demand (peCOD) and adenosine triphosphate (ATP) analysis were used as the major monitoring tools to evaluate **the study of the enhancement of the biological activity in drinking water biofilters by amino acid amendments** (i.e. phenylalanine, tyrosine, and tryptophan).

MATERIALS AND METHODS

- Bench-scale biofilters with filter media of glass beads were fed with dechlorinated tap water (DOC was 1.82 ± 0.15 mg/L and phosphate concentration was 0.35 ± 0.04 mg/L)
- Empty bed contact time (EBCT) of the biofilters was **15-16 min**
- **Phenylalanine, tyrosine, and tryptophan** were added at a target concentration of **3 mg/L**, while the fourth column was maintained as a control column
- Photoelectrochemical oxygen demand (peCOD) & adenosine triphosphate (ATP) analysis were used as tools to quantify substrate and biomass evolution in drinking water biofilters.

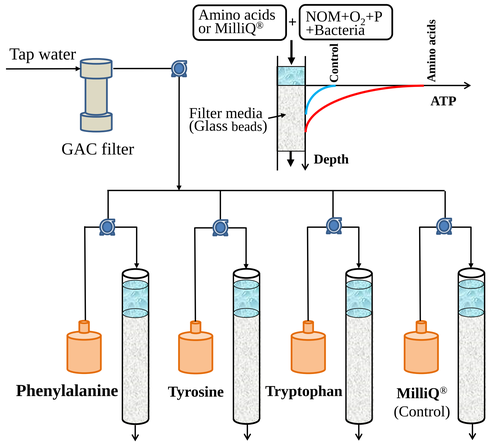


Figure 1. Schematic of biofilters with amino acid amendments

RESULTS AND DISCUSSION

Biomass ATP and predicted growth model

- The biological activity of biomass (i.e. biomass ATP) increased to approximately 1,900-15,000 ng/cm^3 with amino acid amendments
- Different amino acids resulted in various biomass ATP concentrations and specific acuumulation rates (μ_{max}) of biomass at the same target concentration (3 mg/L)
- Biomass ATP data fit with predicted model ($r^2 > 0.95$)

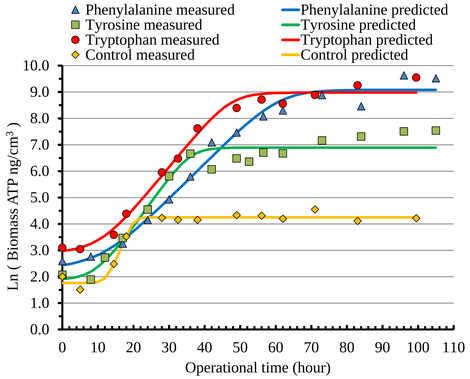


Figure 2. Evolution of measured biomass ATP with the predicted growth model suggested by Baranyi and Roberts (1994)

Table 1. Predicted model parameters

Parameter	Phenylalanine	Tyrosine	Tryptophan	Control
y_o	2.44 ± 0.30	1.91 ± 0.39	2.98 ± 0.24	1.76 ± 0.12
μ_{max}	0.14 ± 0.01	0.19 ± 0.03	0.17 ± 0.02	0.31 ± 0.08
y_{max}	9.08 ± 0.19	6.89 ± 0.15	8.98 ± 0.14	4.25 ± 0.06
r^2	0.98	0.95	0.98	0.97

Note: y_o is initial biomass concentration (ln ATP ng/cm^3)
μ_{max} is the **maximum specific accumulation rate** (h^{-1})
y_{max} is maximum biomass concentration (ln ATP ng/cm^3)

DOC and peCOD

- The average removals of peCOD in the steady-state were greater than DOC
- The degradation times of peCOD were longer than that of DOC

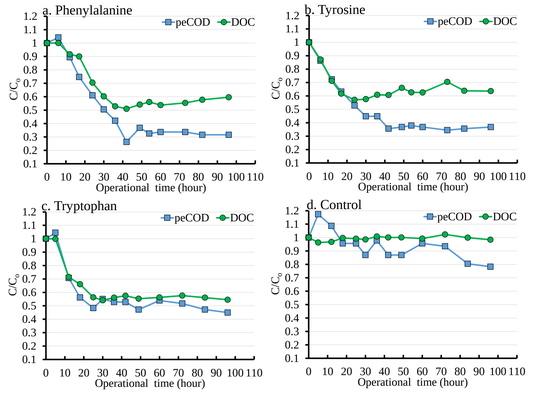
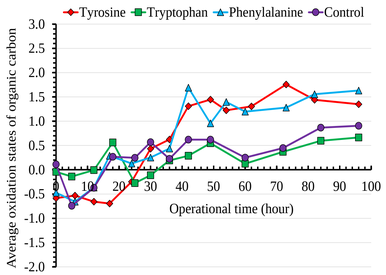


Figure 3. C/C$_o$ of DOC and peCOD in effluent versus operational time

Average oxidation states of organic carbon

- The average oxidation states of organic carbon increased with the operational time, indicating that the organic matter was still being oxidized when DOC removal had already achieved the steady state



Stoichimometic photocatalytic oxidation of organic compounds (Zhao et al., 2004):

$$C_yH_mO_fN_kX_q + (2y - j)H_2O \rightarrow yCO_2 + qX^- + kNH_3 + (4y - 2j + m - 3k)H^+ + (4y - 2j + m - 3k - q)e^-$$

Average oxidation states of organic carbon

$$= \frac{2j - m + 3k + q}{y} = \frac{4(DOC - peCOD)}{DOC}$$

(Contreras et al., 2003)

DOC is in mol C/L and *peCOD* is in mol O_2/L

Figure 4. Average oxidation states of organic carbon calculated by peCOD and DOC

Kinetics of substrate degradation

- The degradation of peCOD and DOC followed the first-order kinetic model:

  $Ln\ (C) = Ln\ (C_o) - kt$

- The ***k*** values of peCOD and DOC were similar, but the degradation times of peCOD were longer than DOC

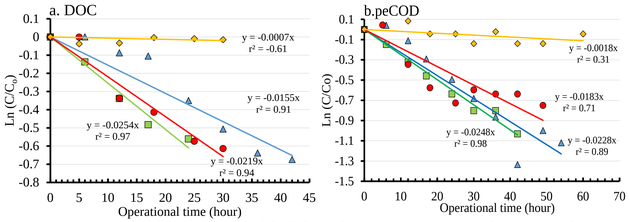


Figure 5. Kinetics of DOC removal (left figure) and peCOD removal (right figure)

Table 2. Kinetic parameters of DOC and peCOD

	k_{DOC} (h^{-1})	r^2 (DOC)	k_{peCOD} (h^{-1})	R^2(peCOD)
Tyrosine	0.0254	0.97	0.0248	0.98
Tryptophan	0.0219	0.94	0.0183	0.71
Phenylalanine	0.0155	0.91	0.0228	0.89
Control	0.0007	-0.61	0.0018	0.31

CONCLUSION

- Amino acid amendments are an effective method to improve the biological activity of biomass in biofilters
- The biomass ATP concentration and the predicted model are good indicators for the enhanced biological activity of biomass with amino acid amendments
- The greater removals and the longer degradation times of peCOD indicate the sensitivity of peCOD in a biological system
- The average oxidation states of organic carbon indicate that peCOD may be an appropriate NOM indicator to couple with biomass ATP

REFERENCE

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If you missed my poster session but you still have questions please contact me at: Bofu.Li@dal.ca or come find me. I'll be here all week!