# Supporting Information

## A proof of concept study for wastewater reuse using bioelectrochemical processes combined with complementary post-treatment technologies

Waris Khan [a,1], Joo-Youn Nam [b,1], Hyoungmin Woo [c], Hodon Ryu [c], Sungpyo Kim [d], Sung Kyu Maeng [a,*], Hyun-Chul Kim [e,*]

[a] Department of Civil and Environmental Engineering, Sejong University, Seoul 05006, Republic of Korea

[b] Jeju Global Research Center, Korea Institute of Energy Research, Jeju-do 63357, Republic of Korea

[c] United States Environmental Protection Agency, Office Research and Development, 26 W. Martin Luther King Dr., Cincinnati, OH 45268, USA

[d] Department of Environmental Engineering, College of Science and Technology, Korea University, Sejong 30019, Republic of Korea

[e] Research Institute for Advanced Industrial Technology, College of Science and Technology, Korea University, Sejong 30019, Republic of Korea

E-mail addresses: waris.uop@gmail.com (W. Khan), jynam@kier.re.kr (J.-Y. Nam), woo.hyoungmin@epa.gov (H. Woo), ryu.hodon@epa.gov (H. Ryu), ub1905ub@korea.ac.kr (S. Kim), smaeng@sejong.ac.kr (S. K. Maeng), animaplus@hanmail.net (H.-C. Kim).

[1] These authors contributed equally to this work.

*Corresponding authors at: Department of Civil and Environmental Engineering, Sejong University, Seoul 05006, Republic of Korea. Tel.: +82 2 34083858 (S. K. Maeng). Research Institute for Advanced Industrial Technology, College of Science and Technology, Korea University, Sejong 30019, Republic of Korea. Tel.: +82 10 73731517 (H.-C. Kim).

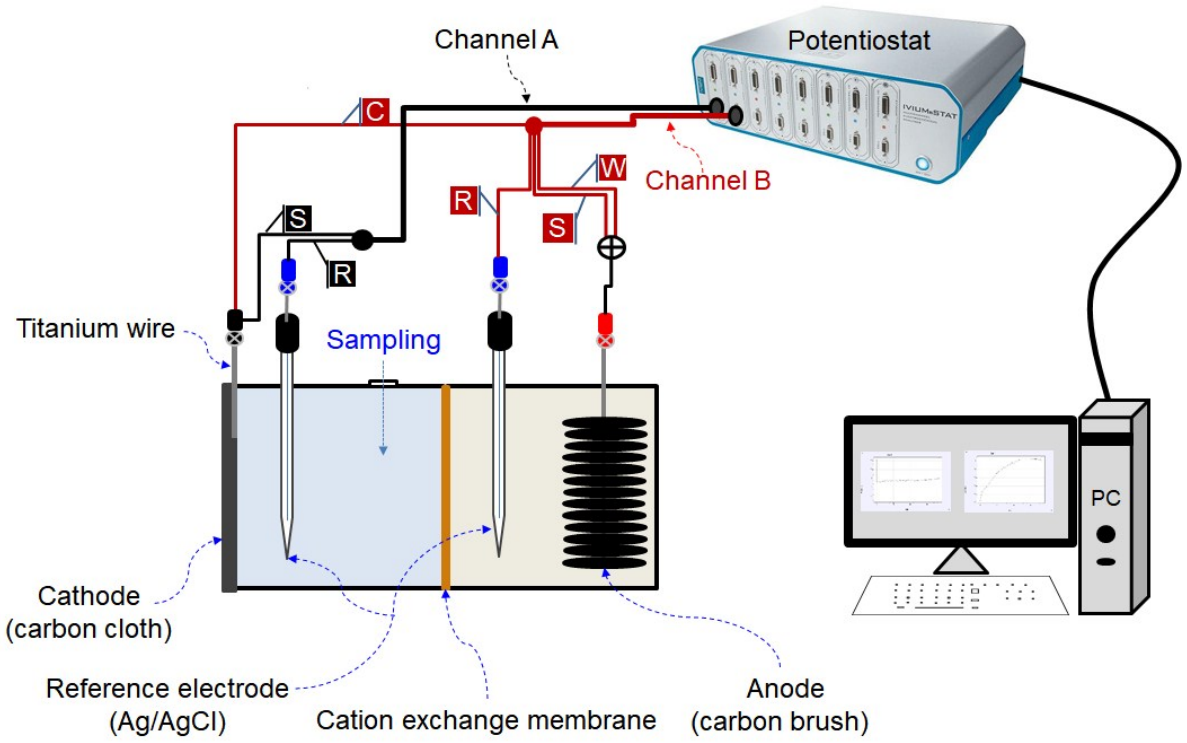


Fig. S1. Schematic of the microbial electrochemical cells (MECs) connected with a potentiostat and data acquisition system. The potentiostat Ch. A: sense wire (S) was connected to the cathode and reference wire (R) was connected to the cathodic reference electrode to measure the cathode potential over time. The potentiostat Ch. B: working wire (W) and sense wire (S) were connected to the anode and reference wire (R) was connected to the anodic reference electrode, while counter wire (C) was connected to cathode electrode. The potentiostat Ch. B maintained the anode potential of MECs at −0.4 V and recorded the current generation during the course of experiment.

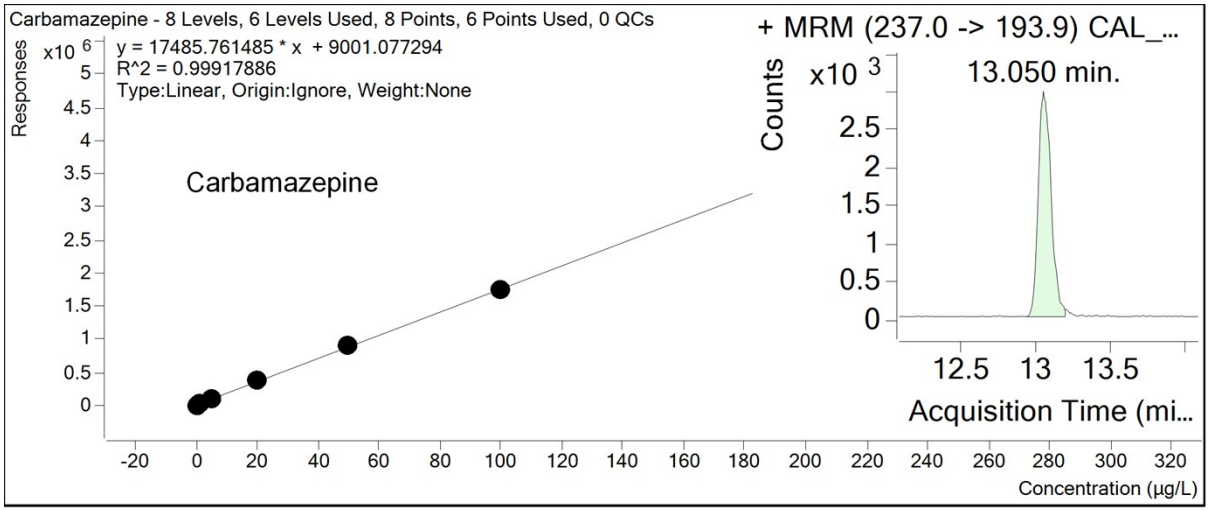


Fig. S2. LC-MS/MS calibration curve of carbamazepine. The chromatographic separation was carried out on a Zorbax Eclipse Plus C18 column (2.1 × 150 mm, 3.5 µm particle size) with mobile phase A (0.1% formic acid in water) and mobile phase B (0.1% formic acid in methanol). The elution rate was set at 0.35 mL $min^{-1}$ and the injection volume was 3 µL. Quantitative and qualitative analysis for carbamazepine were performed by multiple reaction monitoring (MRM). MRM precursor and product ion pairs were selected at the highest peak intensities with different fragment and collision energies.

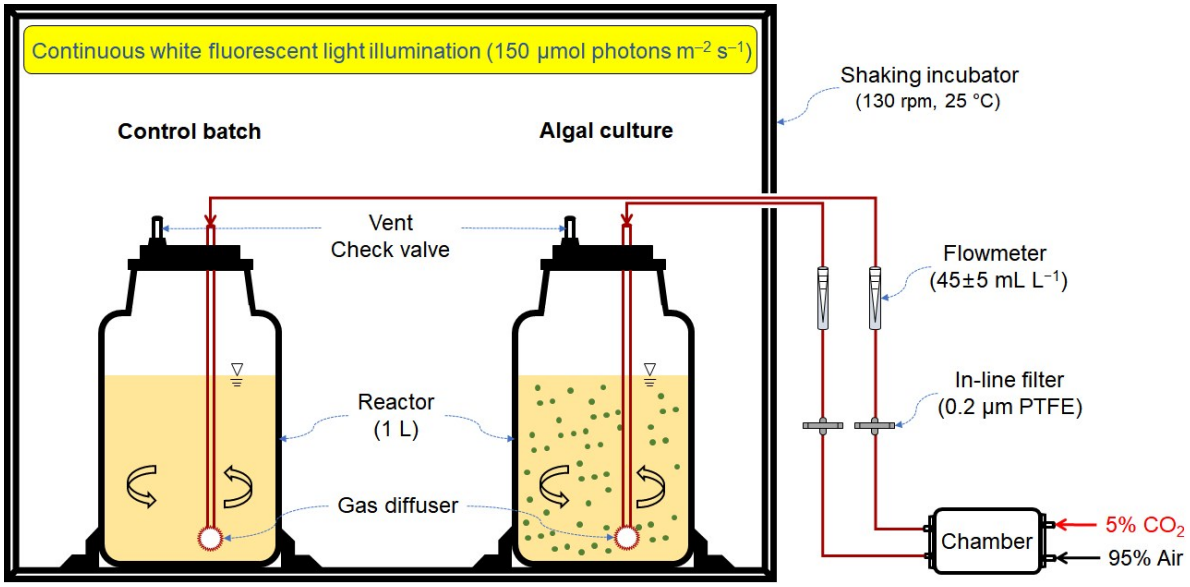


Fig. S3. Experimental set-up for treatment of synthetic MEC effluent with *S. quadricauda* microalgae. We previously determined that *S. quadricauda* can engage in mixotrophic growth in addition to the common photoautotrophic growth when using $CO_2$ as the sole carbon source.

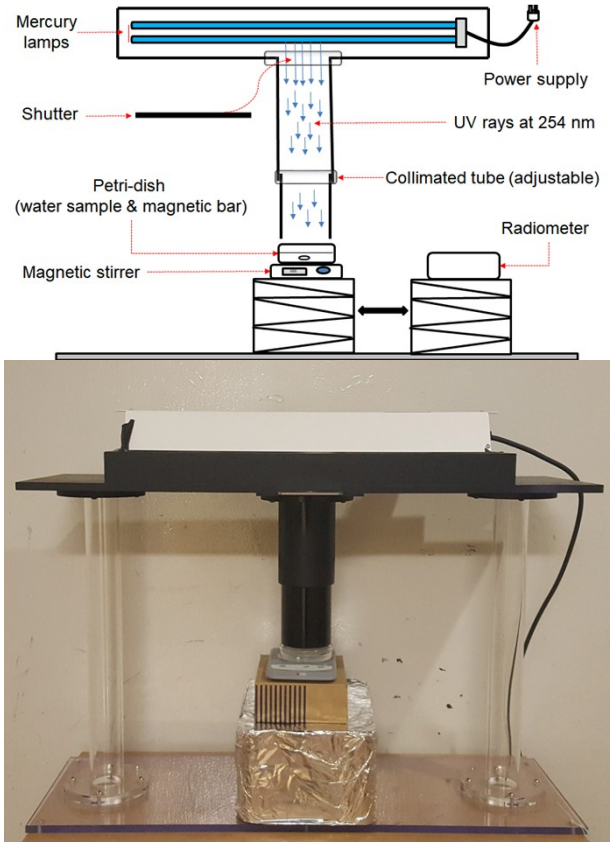


Fig. S4. Collimated beam set-up for advanced oxidation of algal-treated wastewater: schematic and photo of collimated beam devices used in this study. UVC intensity readings were taken at water surface level in Petri dish.

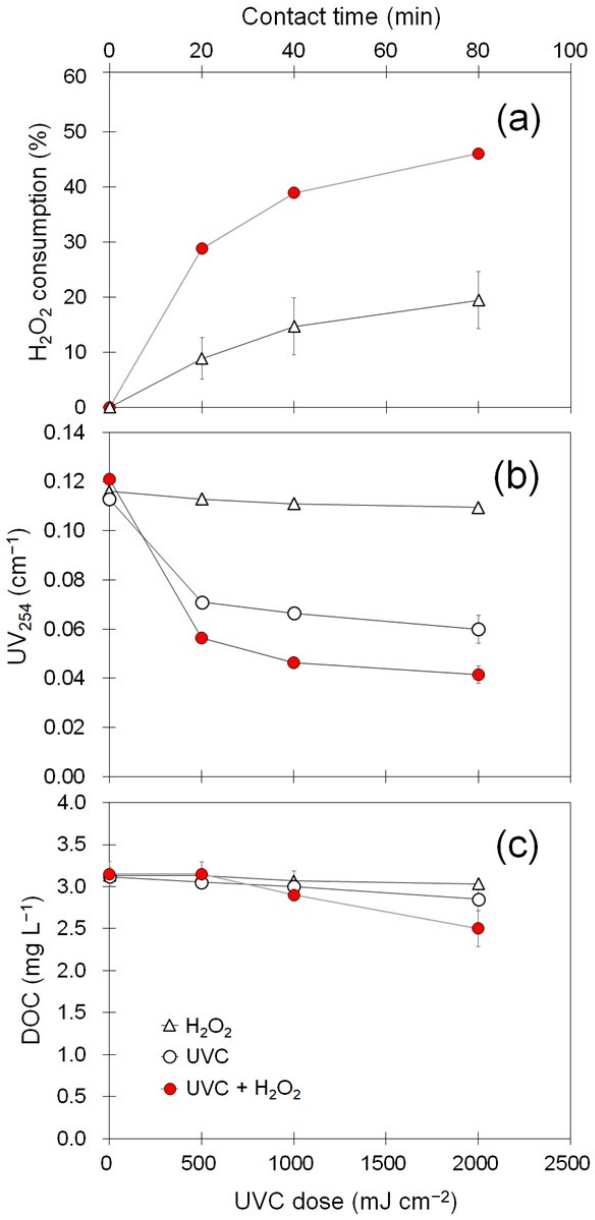


Fig. S5. The consumption of $H_2O_2$ (initial concentration: 10 mg $L^{-1}$) against contact time (a) and the results of batch experiments with algal-treated wastewater at different UVC doses of up to 2000 mJ $cm^{-2}$ (b–c). $H_2O_2$ was liable to decay with time and UVC irradiation accelerated the decomposition of $H_2O_2$ in the wastewater. For both UVC photolysis and UVC/$H_2O_2$, a substantial decrease in $UV_{254}$ was observed upon UVC irradiation at 500 mJ $cm^{-2}$, but insignificant change was found with further increase of UVC dose up to 2000 mJ $cm^{-2}$. If the error bars are larger than the symbols, then the error bars are shown.

**Coulombic efficiency**

Based on the COD removal with microbial electrochemical cells (MECs), the coulombic efficiency was calculated using Eq. S1.

$$Coulombic\ efficiency\ (\%) = \frac{Q}{F \times COD^{e}} \times 100$$

(Eq. S1)

where, $Q$ is the cumulative coulombs, $F$ is the Faraday's constant (96,485 C $mol^{-1}$), and $COD^{e}$ is mole of electrons equivalent to the consumption of organic substrates (as COD) in the anodic chamber determined at the end of MEC runs (8 g $O_2$ = 1 mol electrons).

**$H_2O_2$ conversion efficiency**

Based on the measured $H_2O_2$ concentration and cumulative coulombs at the end of MEC runs, the conversion efficiency from coulombs to $H_2O_2$ was calculated using Eq. S2.

$$H_2O_2\ conversion\ efficiency\ (\%) = \frac{n \times F \times C \times V}{Q} \times 100$$

(Eq. S2)

where, $n$ is mole of electrons equivalent to mole of $H_2O_2$ produced ($n$ = 2), $F$ is the Faraday's constant (96,485 C $mol^{-1}$), $C$ is the measured $H_2O_2$ concentration (mol $L^{-1}$), $V$ is the volume of catholyte (29 mL), and $Q$ is the cumulative coulombs.

**Energy input**

Energy input (kJ) is the electrical energy added to the system and calculated using Eq. S3.

$$\text{Energy input (kJ)} = C \times E_{applied} \qquad \text{(Eq. S3)}$$

where, $C$ denotes the total coulombs transferred in the MEC and calculated by integrating the

current over time and $E_{applied}$ (V) is the different between the cathode and anode potentials.