Supplementary Materials: Removal of Six Estrogenic Endocrine-Disrupting Compounds (EDCs) from Municipal Wastewater Using Aluminum Electrocoagulation

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Background and Preliminary Testing Information

Our first step in this process was to determine which combination of variables (conditions) would provide sufficient removal of the endocrine-disrupting compounds. We began preliminary testing in June 2012. It was important to first establish whether iron or aluminum was the superior choice of blade material. Iron blades were used for four of the preliminary tests (while other conditions were varied) and the same was done with aluminum blades. As seen in the table below, not one of the combined conditions of this first round of testing provided EDC removal.

Table S1. Preliminary Testing, June 2012.

Date	Electrode Material	Pump Setting	Retention Time (seconds)	Volts	Amps	Number of Terminals	Method	Conclusion
5 June 2012	iron	2	32	42	1	2	one pass	No EDC removal
5 June 2012	iron	2	32	52	1.7	2	one pass	No EDC removal
5 June 2012	iron	2	32	102	2.5–4	2	one pass	No EDC removal
5 June 2012	iron	3	20	75	2.3	2	one pass	No EDC removal
5 June 2012	aluminum	2	32	42	1	2	one pass	No EDC removal
5 June 2012	aluminum	2	32	54	1.3	2	one pass	No EDC removal
5 June 2012	aluminum	2	32	102	2.7-3	2	one pass	No EDC removal
5 June 2012	aluminum	3	20	66	1.6	2	one pass	No EDC removal

Our next round of preliminary testing was done in November 2012. For this round, we had to be a bit more aggressive–increasing the power, as well as introducing the variable of an oxidant, just in case that would prove beneficial. After this round of testing, we were able to obtain EDC removal with the conditions highlighted below.

Table S2. Preliminary Testing, November 2012.

Date	Electrode Material	Pump Setting	Retention Time (Seconds)	Volts	Amps	Number of Terminals	Method	Oxidant Added	Conclusion
20 November 2012	iron	2	32	56	13.5	3	one pass		No EDC removal
20 November 2012	iron	2	32	55	13.7	3	one pass	hydrogen peroxide	No EDC removal
20 November 2012	iron	6	60	60–65	13.5–14	3	recirculation		No EDC removal
20 November 2012	iron	7	90	55–60	14	3	recirculation		No EDC removal
20 November 2012	aluminum	2	32	66	13	3	one pass		No EDC removal
20 November 2012	aluminum	2	32	72	13	3	one pass	hydrogen peroxide	No EDC removal
20 November 2012	aluminum	6	60	80	13.5	3	recirculation		No EDC removal
20 November 2012	aluminum	8	120	80–95	13.5	3	recirculation		Removal obtained for majority of EDCs

In order to ensure that this combination of conditions highlighted above was truly effective against EDCs, we performed a replicate experiment in July 2013 utilizing these same conditions. We obtained the same results as the preliminary testing—removal of the EDCs. We were then confidant to move forward with the laboratory experiment which serves as the basis of this study.

Table S3. Replicate Experiment for Verification of Optimal Parameters.

Date	Electrode Material	Pump Setting	Retention Time (s)	Volts	Amps	Number of Terminals	Method	Oxidant Added	Conclusion
1 July 2013	aluminum	8	120	80–95	13.5	3	recirculation	No	Replicate experiment; optimal parameters verified

The Optimal Parameters Are as Follows, along with a Brief Explanation:

- Aluminum blades as the electrode material—through our preliminary testing, we achieved EDC removal with the aluminum blades while EDC removal was insufficient with the iron blades.
- Sample retention time of 2 min—the sample retention time is the time the sample actually spends in the EC reaction chamber. We controlled the pump speed so that the sample was in the reaction chamber for 2 mins per liter of sample.
- Volts held in the range of 85 to 98—when we performed the preliminary tests with lower voltages (outlined above), the EDC removal was not adequate, leading us to use the higher voltages in this study. However, The Powell Water Electrocoagulation systems are designed to accommodate high voltages (voltages are divided inside the chamber by the sacrificial plates (*i.e.*, blades) such that the voltage between the plates is actually very low) and low amperes. This design is more energy-efficient and allows for significant reduction in conductor size, as wire size is based upon amperes and not voltage. Additionally, this design of low amperes allows for large flow rate EC reaction chambers which further reduces capital cost of Electrocoagulation treatment. The laboratory-scale unit used for this study was scaled in relation to the full-size industrial units.
- Amperes held in the range of 8.5 to 15.5—the volts were controlled and the amperes recorded. The purpose of this laboratory testing was to determine if electrocoagulation could have a beneficial effect on the EDC contaminants. The focus was not on optimization of energy versus % removal. Energy optimization could be performed with additional testing in subsequent research.
- Three-lead arrangement of electrical connections—this can be visualized in Figure 3 of the manuscript. The two-lead arrangement would only provide electrical connections to blades 1 and 9. The three-lead arrangement introduces the alligator clips which now provide electrical connections to blades 1, 5, and 9. In the tables above, you can tell if a test utilized a two-lead or three-lead arrangement based on the number of terminals.
- Recirculation method—the recirculation method allows the sample to enter the EC reaction chamber, exit to the inflow tube, and then re-enter the chamber again. This recirculation was done for 2 min per liter of sample.