# Application of Manganese Oxide-Coated Media for Reagent-Free Oxidation of BPA

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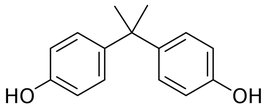
## Introduction

- Bisphenol A (BPA) is a polymer used in the production of polycarbonate plastics and epoxy resins and a potent endocrine disruptor.
- BPA is poorly soluble in water; as these products degrade over time BPA can contaminate water sources.
- BPA is removed by preexisting processes in water treatment plants.[1]
- ~15% of the United States relies on private wells for drinking water and do not receive pretreated water.[2]
- Limited practical treatment options exist for BPA removal in small-scale and isolated systems.
- Manganese oxide ($MnO_x$)-coated media is known to oxidize BPA, but this approach requires the feeding of chemicals for surface regeneration.[3]
- This is impractical for small-scale or isolated systems, which do not have capacity for chemical storage and dosing.




## Objective

**To validate reagent-free electrochemical regeneration of $MnO_x$-coated media for the oxidative removal of BPA from drinking water.**

## Materials

### Manganese Oxide-Coated Media

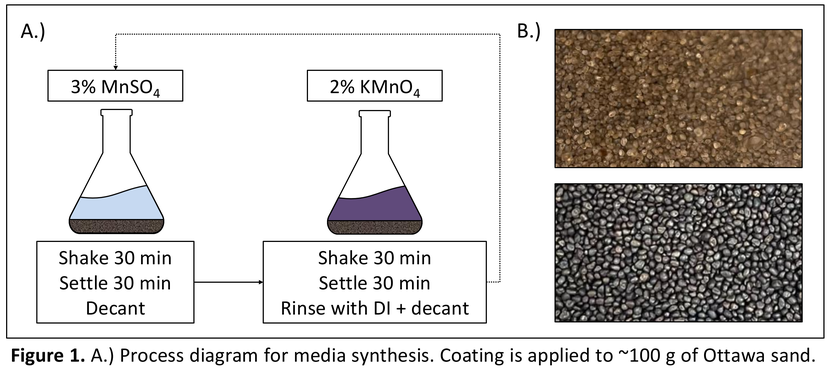



**Figure 1.** A.) Process diagram for media synthesis. Coating is applied to ~100 g of Ottawa sand. B.) Media prior to repetitive coating (top), and after (bottom).

### Synthetic Raw Water

**Table 1.** Composition of synthetic raw water used as background matrix for all column tests.

| | |
|---|---|
| Alkalinity | 25 mg/L as $CaCO_3$ |
| Calcium (Ca) | 10 mg/L |
| Sodium Chloride (NaCl) | 25 mg/L |

## Methods

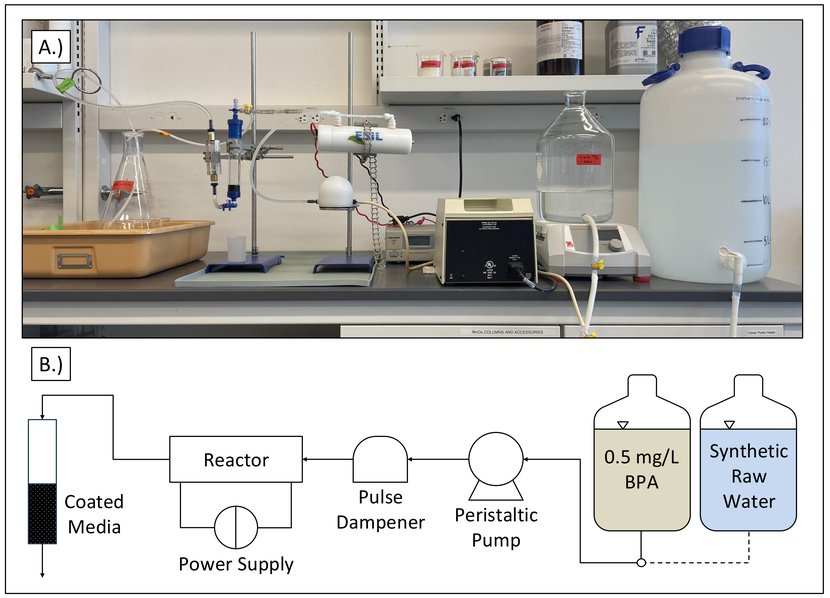



**Figure 2.** A.) Bench-scale setup for all detailed experiments (Figures 4-6). B.) Process diagram for setup shown in Figure 2A. For chemical regeneration (Figure 6A), reactor was disconnected.

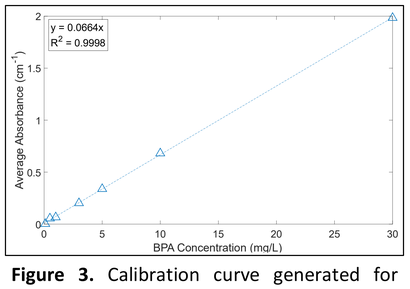



**Figure 3.** Calibration curve generated for measurement of BPA by spectrophotometer at 276 nm. Triplicate absorbance readings were averaged for each .

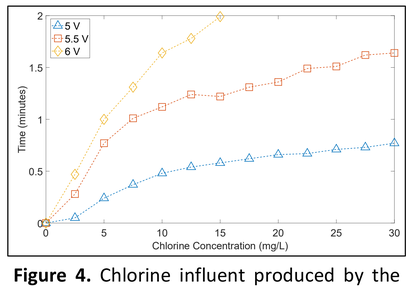



**Figure 4.** Chlorine influent produced by the reactor at 5, 5.5, and 6 V. Measurements for 6 V exceeded 2 mg/L after 15 minutes.

**Table 2.** Procedural details for media regeneration and BPA oxidation tests.

| Chemical Regeneration | Electrochemical Regeneration | Longevity Tests |
|---|---|---|
| Media shaken in 100 mL of 20 mg/L $Cl_2$ for > 2 hours | Reactor on 5.5 V and 2.1 A or 6.0 V and 2.1 A | 0.5 mg/L BPA run at 4.0 mL/min |
| Rinsed with tap water and drained | Synthetic raw water run at 50.0 mL/min until influent $Cl_2$ = effluent $Cl_2$ | All samples passed through 0.45 µm filter before measurement |
| | $Cl_2$ measured by HACH Method 8167 (Standard Methods 4500) | BPA measured as absorbance by spectrophotometer at 276 nm |

## Results

### Electrochemical Chlorine Production

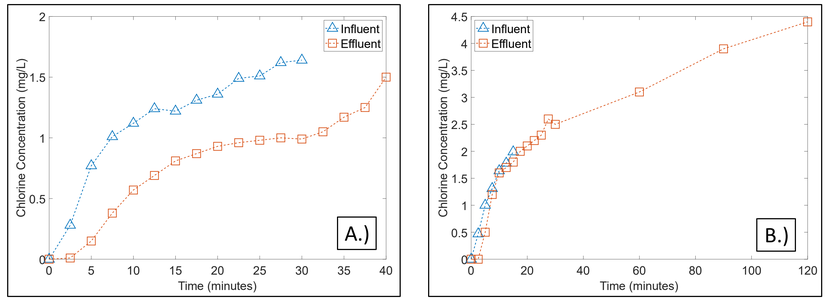



**Figure 5.** A.) Electrochemical regeneration of fully expended media via production of chlorine at 5.5 V for 40 minutes. B.) at 6.0 V for 2 hours.

### Oxidation of BPA by $MnO_x$ Coated Media

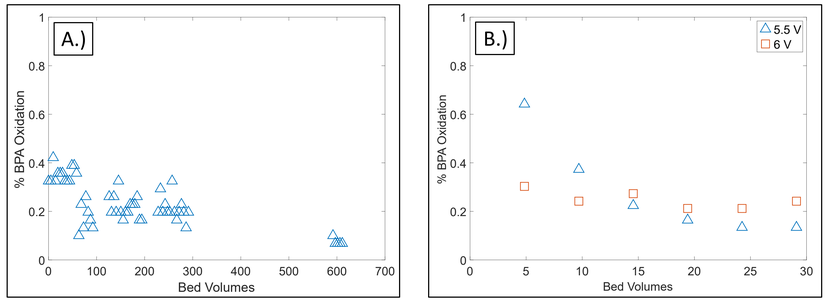



**Figure 6.** A.) Oxidation of BPA by $MnO_x$-coated media regenerated chemically. B.) regenerated electrochemically at 5.5 and 6.0 V (Figures 5A and B). Chemically regenerated media was run until the media was fully expended; electrochemically was not.

## Conclusions and Future Work

- Electrochemically regenerated media at 6 V for 2 hours demonstrates similar oxidation of BPA as chemically regenerated media.
- Iterative tests are necessary to determine the exact voltage and run time for optimal electrochemical regeneration.
- BPA detection by spectrophotometer is effective for proof of concept, however, more rigorous methodology is necessary for measurement at low concentrations.
- It is likely that greater coating density on the media will yield greater oxidation of BPA- more densely coated media should be synthesized, characterized, and used in the column.

## References

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[2] DeSimone, L. A. 2009. "Quality of Water from Domestic Wells in Principal Aquifers of the United States, 1991-2004." Scientific Investigations Report. United States Geological Survey. https://doi.org/10.3133/sir20085227.

[3] Charbonnet, J. A., Y. Duan, van Genuchten, and D. L. Sedlak. 2018. "Chemical Regeneration of Manganese Oxide-Coated Sand for Oxidation of Organic Stormwater Contaminants." Environmental Science & Technology, 52 (18): 10728–10736. American Chemical Society. https://doi.org/10.1021/acs.est.8b03304.

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