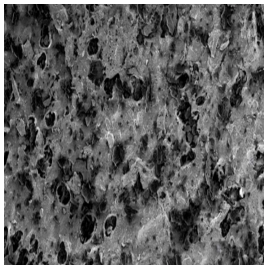
Jun 20, 2024

Evaluation of point-of-use treatments and biochar to reduce 1,2,3-trichloropropane (TCP) contamination in drinking water



DOI
dx.doi.org/10.17504/protocols.io.14egn3496l5d/v1

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OPEN ACCESS

DOI: dx.doi.org/10.17504/protocols.io.14egn3496l5d/v1

Protocol Citation: B Hope Hauptman, Colleen C Naughton 2024. Evaluation of point-of-use treatments and biochar to reduce 1,2,3-trichloropropane (TCP) contamination in drinking water. **protocols.io https://dx.doi.org/10.17504/protocols.io.14egn3496l5d/v1**

Protocol status: Working
We use this protocol and it's working

Created: September 25, 2023

Last Modified: June 20, 2024

Protocol Integer ID: 88327

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Abstract

In this study, we explore the potential of commercially available off-the-shelf pitcher point-of-use filters for reducing TCP levels in tap water, as consumers lack evidence-based information on these treatments' effectiveness in removing TCP. We also examine carbon sources from biochar made from almond shells to remove TCP using batch isotherm analysis. Biochar could serve as a sustainable alternative to the current imported coconut and coal-based feedstocks for TCP-contaminated water.

Guidelines

Procedures are performed at room temperature approximately 20 °C (specific temperature will be recorded)

Materials

1,2,3-trichloropropane, HCl

Safety warnings

- All steps involving the dilution of the TCP stock solution should occur in the fume hood
- Safety splash goggles, lab coat, and gloves should be worn for all steps

Section 1: General information

1 **General**

- Procedures were performed at room temperature **at** approximately 20 °C (the recorded temperature was 21.5^{O}C).
- Samples collected for GC-MS testing at BSK Analytical Laboratories in Fresno, California were held at 4^{O}C for a maximum of 4 days before being transported on ice for analysis.

Safety information

- All TCP dilution steps using concentrated TCP stock solution occurred in a fume hood
- Safety splash goggles, lab coat, and gloves were worn for all steps **PPE**

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Section 2: Source Water

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1. Tap water was collected directly from the tap at the University of California, Merced, Sustainability Research Engineering (SRE) building from the general tap (labeled non-potable untreated tap water).
2. The temperature, pH, conductivity, nitrate level, TDS, and TOC of the sample water were tested.
3. Collected source water was spiked with TCP to a concentration of or close to 200 ppt with analytical grade 1,2,3-trichloropropane (see next section).

Section 3: Spiking source water with TCP

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1. A 240 mL amber bottle was filled with source water and sealed with a mininert cap.
2. A Hamilton syringe was used to inject 1 gram of TCP into the 240 mL amber bottle. As TCP is a dense non-aqueous phase liquid it sank to the bottom where it was visualized as a “blob”.
3. Amber bottle (solution #1) will remain in fume for 14 days so that the solution is saturated with TCP at which the theoretical concentration of the solution will be 1.75 g/L TCP (solubility of TCP).
4. Another 240 mL bottle with a mininert cap was filled with tap water, capped, and massed. The water in the flask was at the brim to ensure no headspace (Solution #2).
5. A glass Hamilton syringe was used to remove a specific amount of Solution #1 (using dilution equation $V_1C_1=V_2C_2$) and inject the solution into solution bottle #2.

6. Solution #2 was then used to spike source water in carboys for the point-of-use experiment and the individual Erlenmeyer flasks containing biochar for the isotherm experiments (using dilution equation $V_1C_1=V_2C_2$).

Section 4: Efficiency of pitcher point-of-use (P-POU) filters to remove TCP from tap water

5 **Filter pre-conditioning**

1. Each P-POU device was first pre-conditioned according to the manufacturer's recommendations.
2. For Brita, the pitcher, lid, and tray were rinsed with soapy water and rinsed well. The carbon filter was rinsed for 15 seconds under the tap, and the first three pitchers of water were discarded.
3. For PUR, the pitcher, lid, and tray were rinsed with soapy water and rinsed well. The carbon filter was rinsed for 15 seconds under the tap.
4. For ZeroWater, the pitcher, lid, and tray were rinsed with soapy water and rinsed well. The carbon filter was rinsed for 15 seconds under the tap, and the first pitcher of water was discarded.
5. Experiments for each filter type were conducted in triplicate.

6 **Removal Efficiency**

1. Following similar methods presented in Anumol et al. (2015), spiked water in the carboy was fed to the P-POU filters in 1-L volumes (by hand, using a glass graduated cylinder) followed by a 30-second equilibration time between additions.
2. Approximate flow rates for each of the three filters were measured during the experiment, in seconds using a stopwatch.
3. For the Britta and PUR, 37.5 liters of spiked source water was fed to each filter according to the manner stated above. For the ZeroWater, 21.25 liters were added to the filter, after which a sample was stored at 4^0C for analysis. Approximate Maximum Estimated Lifetimes (MELs) for the three brands of filters are 151 L (for both Brita and PUR) and 85 L (for Zerowater).
4. Filtered samples were collected for each filter when the percentage of water passed through the filters was equal to 0, 25, 50, 75, 100, and 125% of the manufacturer's expected lifetime (MEL).
5. To check how much TCP degraded from the stored water during the experiment, control samples were taken from the source water container when the filtered water was sampled.
6. Effluent samples will be capped with no headspace in 40mL vials with HCl preservative and the samples will be stored in the refrigerator at 4^oC until collected for analysis.
7. The analytical lab uses California's Department of Public Health's Sanitation and Radiation Laboratories (SRL) method SRL524.2 liquid-chromatography and mass spectrometry for TCP detection with a lower limit of 0.005µg/L (Okamoto et al., 2002).

7 **Control**

1. One control was used for each pitcher type consisting of the pitcher without a carbon filter insert.
2. One liter of spiked water was added to each control pitcher and sampled at the same time samples were taken from the experimental group.

Section 5: Plastic sorption analysis

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1. Spiked water was added to three *polypropylene* bottles with a 250mL volume, capped, taped with parafilm, and stored at room temperature for five days (Group #1).
2. Spiked water was added to three *glass bottles* with a 250mL volume, capped, taped with parafilm, and stored at room temperature for five days (Group #2).
3. Water from Groups #1 and 2 was sampled after 5 days and stored at 4^{o}C for analysis.
4. The analytical lab uses California's Department of Public Health's Sanitation and Radiation Laboratories (SRL) method SRL524.2 liquid-chromatography and mass spectrometry for TCP detection with a lower limit of 0.005µg/L (Okamoto et al., 2002).

Section 6: Isotherm sorption of 1,2,3-Trichloropropane (TCP) with Almond Biochar

9 **Spiking Water for Isotherm Tests**

<See Section #3 above>

10 **Activated carbon production and sampling**

1. The almond shell biochar used for this study was produced by slow pyrolysis of almond shells at the University of California Merced by Dr. Gerardo Diaz's lab
2. Carbon samples were sorted by size with an automatic sieve shaker (WS Tyler model RX-29) and char sizes of 500-1000 um (passing through a 1000-micron screen and retained on a 500-micron screen) were collected and used for the isotherm analysis.
3. Since samples are sorted for particle size when dry, they were not oven-dried.
4. **So** that selected samples contain a similar distribution of particle sizes, a riffle splitter was used to fractionate the samples of individual isotherm tests.

11 **Isotherm procedure (derived from ASTM, 1980 and Schneiter et al., 1985)**

1. Glass Erlynmeyer flasks, Teflon caps, and glass beads were acid-washed with 2 molar HCl and allowed to air dry.
2. The mass of flasks with a Teflon cap and 3 glass beads was obtained with an electronic balance.
3. Selected carbon masses were added to each of the flasks from the previous step and the combined mass was recorded (as a first pass, 0.5mg, 1mg, and 5mg masses of biochar were used to determine the appropriate sorption range bracket).
4. Using a beaker, source water was slowly poured into each flask with no headspace.
5. A Hamilton syringe was then used to spike the source water in each flask with a specific amount of spiking solution (see Section #3 above) for a concentration of approximately 0.2 µ g/L of TCP.

6. The resulting flasks were capped and their masses were obtained.
7. The glass syringe mass was obtained empty and with 1 mL of source water.
8. The mass of 1 mL of source water was used to calculate the volume of water in flasks.
9. Flasks were then placed on a platform agitator @250 rpm for 48 hours. After 48 hours the flasks were allowed to settle.
10. The solutions in the flasks were then decanted into sample bottles and held at 4^{o}C for analysis.
11. The analytical lab uses California's Department of Public Health's Sanitation and Radiation Laboratories (SRL) method SRL524.2 liquid-chromatography and mass spectrometry for TCP detection with a lower limit of 0.005µg/L (Okamoto et al., 2002).

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