

 **BRITA**[®]

Water Filtration

Allison Wexler, Nathan Gong, Rose Razavi, Philia Zhang

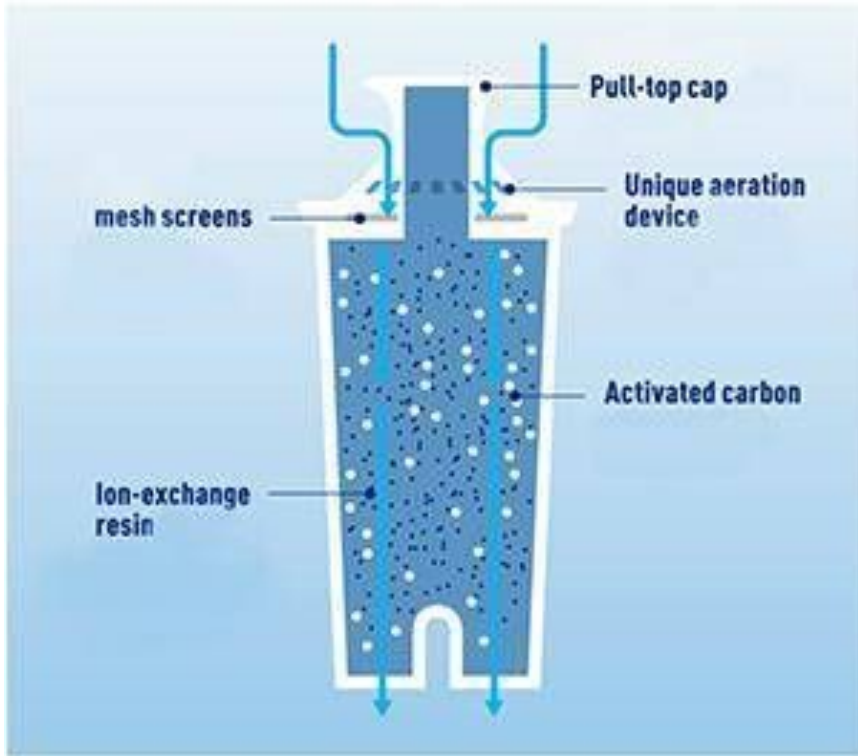
—APPLICATIONS:

- potable water
- biotechnology
(fermentation processing, separation of components from biological fluids)
- industrial processes
(waste stream treatment, recovery of process chemicals)
- medical procedures
- semiconductor fabrication processes
(using ultra purified liquids)
- fluid recirculation
(aircraft and spacecraft)

—WELL KNOWN METHODS OF WATER FILTRATION:

- reverse osmosis
- distillation
- ion-exchange
- chemical adsorption
- coagulation
- filtering
- retention

THE BRITA DIFFERENCE



Uses coconut-based
activated carbon
and synthesized
ion-exchange
resins as sorbent

Hatch, Jacob. "The Brita Infinity Smart Water Filter Pitcher Review."
Hydration Anywhere, 12 Mar. 2017,
hydrationanywhere.com/brita-infinity-smart-water-filter-pitcher-review/.

The title 'Background Information' is centered at the top of the slide. It is flanked by two large, blue, stylized shapes that resemble the letter 'L' or a bracket, one on the left and one on the right. The text is in a bold, dark blue font.

Background Information

Purpose of Brita® Filter:

- adjusts pH, taste, colour, and odour
 - removes contaminants from fluids,
 - small particles, suspended solids, allergens, bacteria, microorganisms, intentionally introduced biotoxins, pesticides, toxic metals (lead, arsenic, mercury), chlorine (a water disinfectant), nitrogen (found in fertilizers)
- And more, such as....

Here's What Brita® Reduces or Removes from Tap Water



Faucet



Standard



Bottle



Dispenser



Stream



Longlast

Chlorine (Taste & Odor)



Copper



Cadmium



Mercury



Lead



Asbestos



Benzene



TTHMs



Cryptosporidium / Giardia



Atrazine



Lindane



Trichloroethylene (TCE)



Particulate Class I



Zinc




Objective

The goal of this experiment was to determine the effectiveness of a Brita Filter at removing calcium ions from tap water.



Experimental Protocol

- **Our method:**
 - Collect 10 samples of water filtered by the Brita Filter.
 - Prepare 3 standard calcium solutions at 0.1, 1, and 10 mg/L
 - Calibrate Atomic Absorption Spectrum and then test the samples
 - **Alternative method:**
 - Prepare a calcium carbonate CaCO_3 solution to standardize a solution of ethylenediaminetetraacetic acid (EDTA)
 - Collect 3 standards (tap water that has been passed through the filter)
 - Perform titrations with the EDTA solution of known concentration against the calcium standard samples of unknown concentration.
- 

Hypothesis

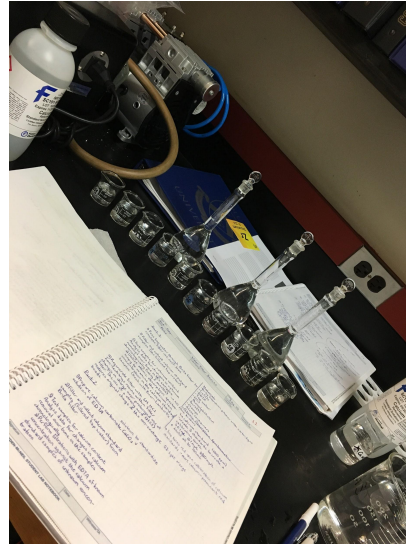
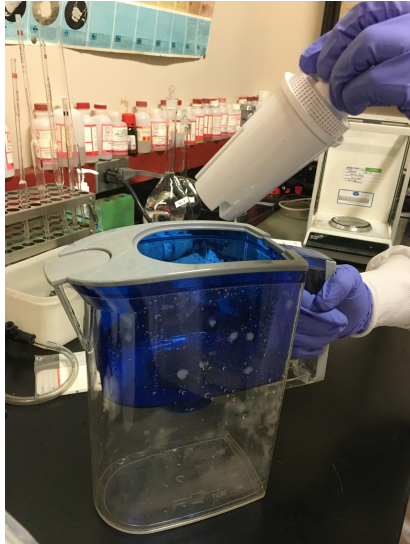
The Brita filter will remove Ca^{2+} ions from tap water less effectively with continual use. Therefore, samples taken towards the end of the experiment will have a higher concentration of Ca^{2+} ions than samples taken at the beginning.



Collecting Samples

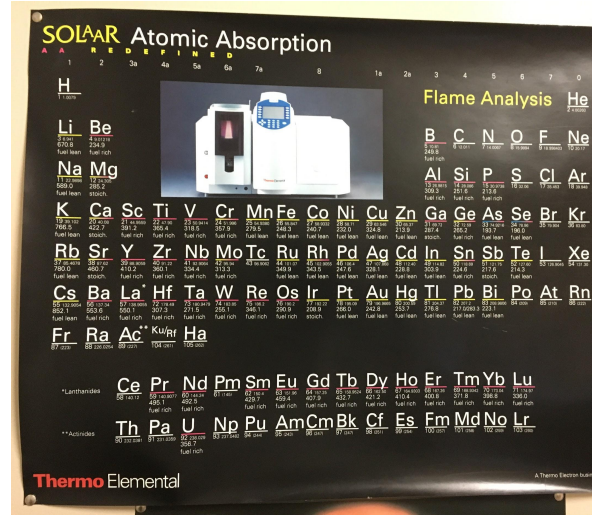
Step 1: Simulate Brita filter use by passing tap water through the filter

Step 2: Filter and collect calcium samples



Prepare Atomic Absorption Spectrometer

Step 3: Prepare 3 standard calcium solutions at 0.1, 1, and 10 mg/L



Calibration

Step 4: Calibrate atomic absorption spectrometer

Select Folder icon to open calibration page

The screenshot displays the SOLAAR M AA System software interface. The main window is titled "Results - natoparticles.nir" and contains a table with calibration data. A red arrow points to a folder icon in the top toolbar, with the text "Select Folder icon to open calibration page" next to it.

Sample ID	Signal	(Signal)	sd	Concentration	Corrected Concentration
Analysis 117					
	Abs		1289139		7.172915
Blank			0.0014	0.0000	
Standard 1			0.0010	0.1000	
Standard 2			0.0007	1.0000	
Standard 3			0.0009	2.0000 U	
Analysis 116					
	Abs		1198032		7.927815
Blank			0.0007	0.0000	
Standard 1			0.0005	0.1000	

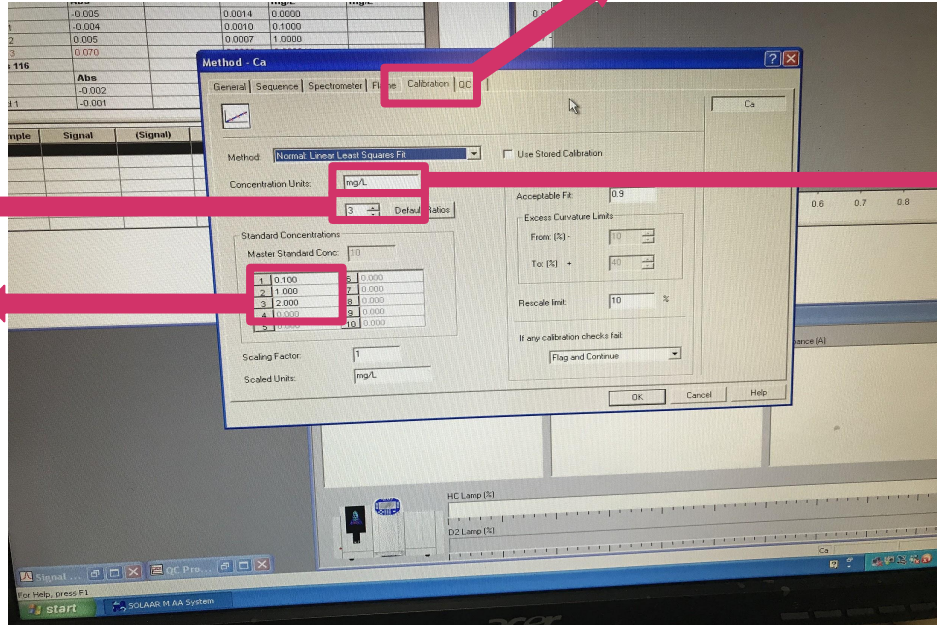
Below the table, there are sections for "Re-sample" and "MEAN". The "Re-sample" section has columns for Signal, (Signal), Rate, and MEAN. The "MEAN" section has columns for Signal, (Signal), %RSD, sd, Concentration, Corrected Concentration, and Auto-Dilution.

On the right side, there is a graph titled "Segmented Fit" showing a linear relationship between Concentration (x-axis, 0.0 to 1.0) and Abs (y-axis, 0.0 to 1.0). The graph shows a single data point at approximately (0.1, 0.1) and a horizontal line at y=0.1.

At the bottom, there is a "Spectrometer Status" window with fields for Wavelength (nm), PMT Voltage (V), and Absorbance (A). Below these fields is a diagram of the spectrometer with labels for HC Lamp (1) and D2 Lamp (1).

Calibration cont.

1. Select Calibration tab
2. Change units
3. Select number of standards
4. Enter concentrations of each standard

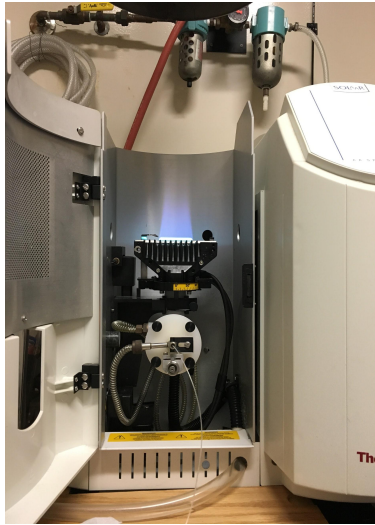


Data Gathering

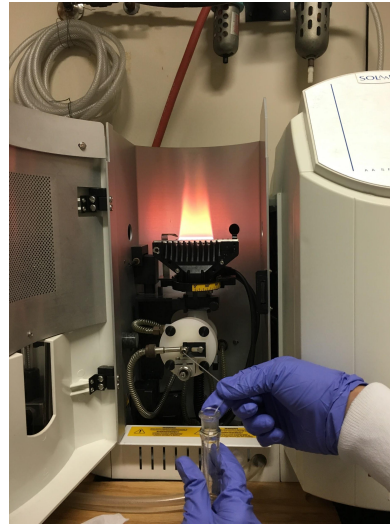
Step 5: Analyze calcium samples using atomic absorption spectrometry



Before experiment started

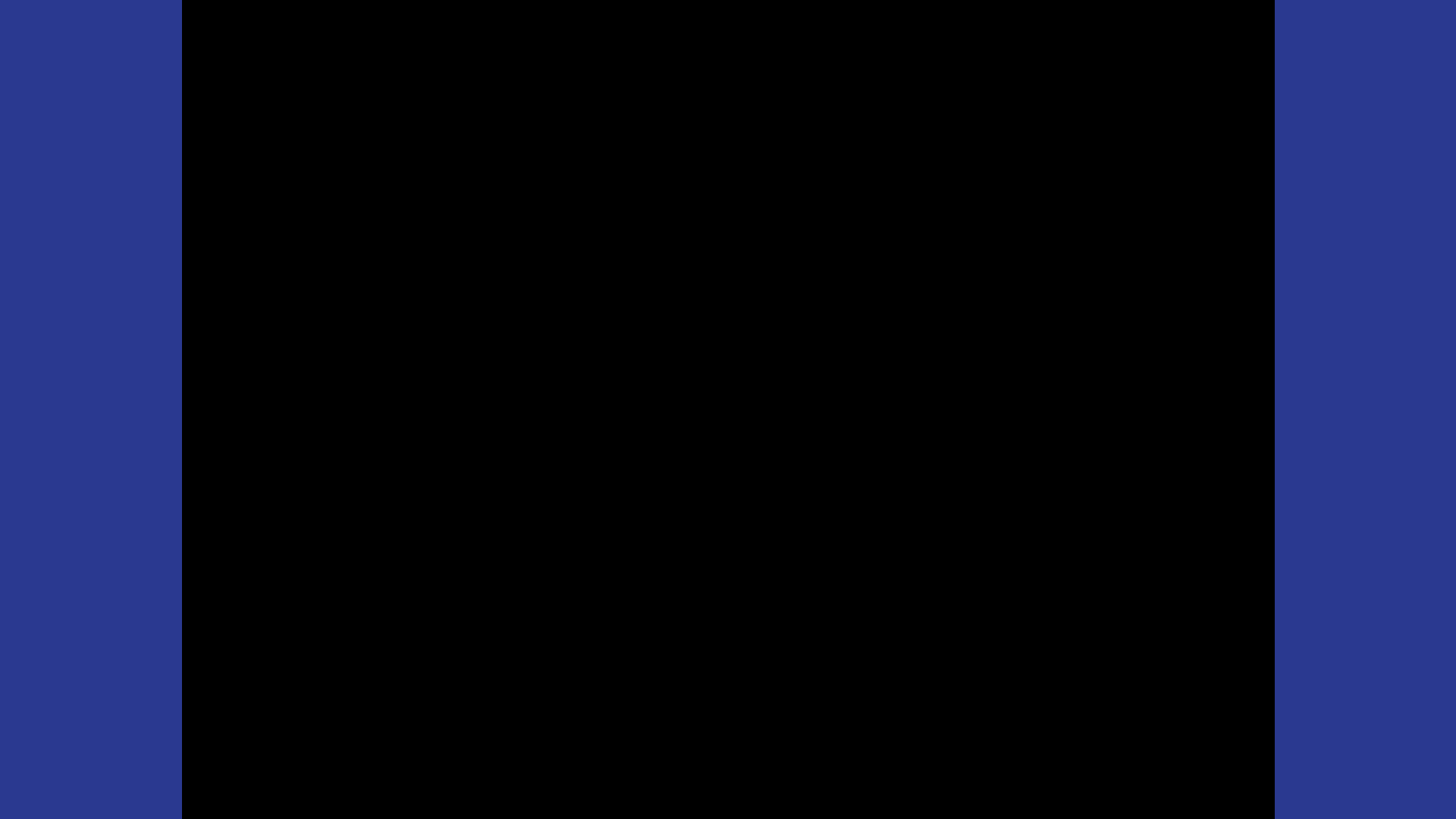


After flame was adjusted



With calcium standard

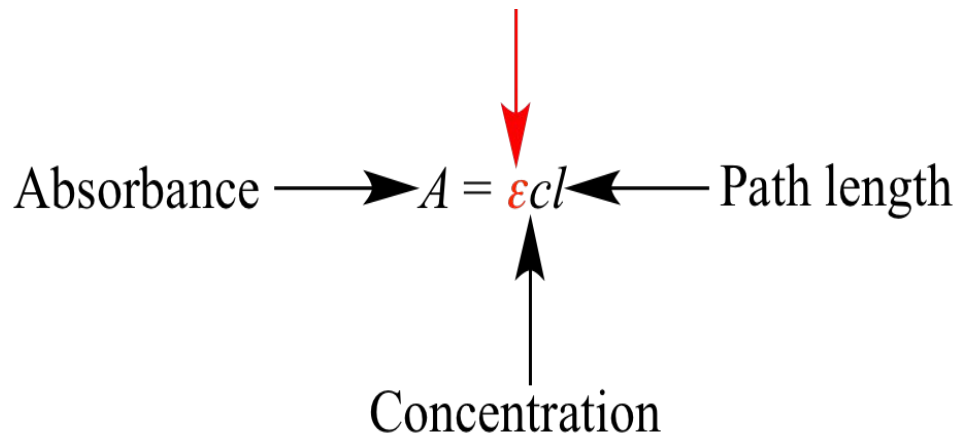




Double-Checking Data

Step 6: Check using Beer-Lambert's Law

Molar Extinction Coefficient



A diagram illustrating the Beer-Lambert Law equation, $A = \epsilon cl$. The equation is centered, with the Greek letter epsilon (ϵ) in red. Three arrows point to the variables: a red arrow points down to ϵ from the text 'Molar Extinction Coefficient' above; a black arrow points right to c from the text 'Concentration' below; and a black arrow points left to l from the text 'Path length' to the right. The text 'Absorbance' is to the left of the equation, with a black arrow pointing right towards the A .

$$\text{Absorbance} \longrightarrow A = \epsilon cl \longleftarrow \text{Path length}$$

Concentration

Calculations using Beer-Lambert's Law

c (mg/L)	Calculated Absorbance	Actual Absorbance
1.649	1.596E-2	1.400E-2
8.369E-1	8.093E-3	6.000E-3
7.695E-1	7.441E-3	5.000E-3
6.219E-1	6.012E-3	4.000E-3
9.785E-1	9.462E-3	7.000E-3
7.555E-1	7.306E-3	5.000E-3
1.233	1.193E-2	1.000E-2
1.283	1.241E-2	1.000E-2
1.083	1.047E-2	8.000E-3
1.298	1.212E-2	1.000E-2

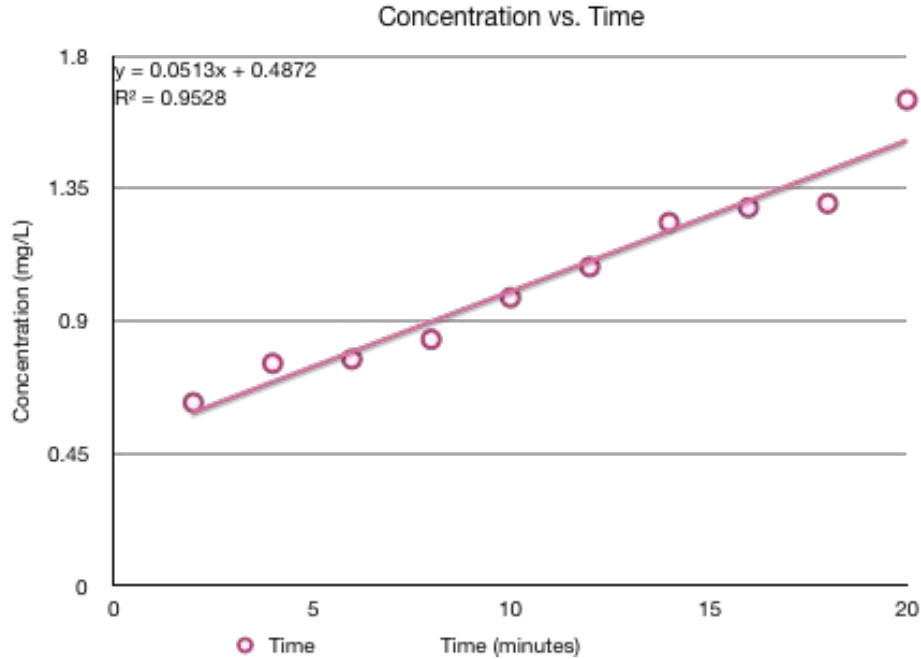
Line of best fit: $y=0.00967x - 0.0022$

Beer-lambert's Law: $A = \epsilon l c$ $\epsilon l = 0.00967$

$$A = (0.00967) c$$

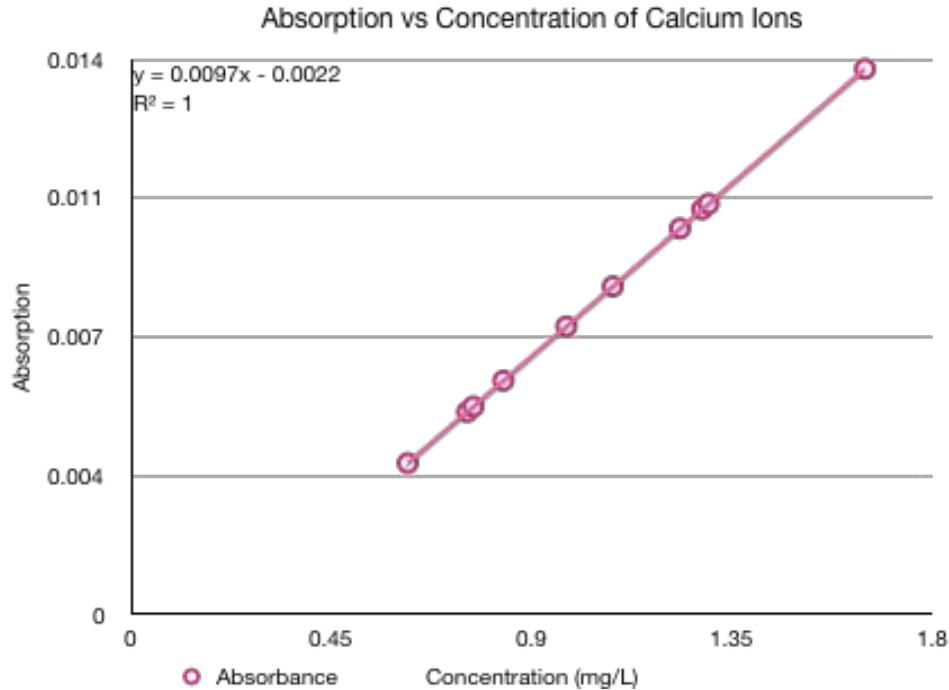


Experimental Errors



Errors in dilutions and calibrations

Data



Concentration (mg/L)	Absorbance
0.6219	3.813E-3
0.7555	5.106E-3
0.7695	5.241E-3
0.8369	5.893E-3
0.9785	7.262E-3
1.083	8.271E-3
1.234	9.732E-3
1.284	1.021E-2
1.298	1.035E-2
1.650	1.375E-2

Results

A linear regression was performed on our collected experimental data. The regression is $Y = 0.0097X - 0.0022$ where Y represents absorbance and X represents concentration.

The line showed an upward trend, indicating a decline in the filter's ability to collect calcium ions.



Conclusion

Hence, our hypothesis is correct. With every usage, the Brita filter showed less effectiveness in removing calcium ions. Consequently, the company producing Brita filters must inform consumers of of deterioration in filter performance and advise on the frequency of the filter replacement.



References

A water treatment experiment (chemical hardness) for nonscience majors. (n.d.). Retrieved from

<https://pubs.acs.org/doi/pdf/10.1021/ed070p414>

Beer's Law Tutorial. (n.d.). Retrieved from http://www.chem.ucla.edu/~gchemlab/colorimetric_web.htm

Gylienė, O., & Višniakova, S. (2008). Heavy Metal Removal from Solutions Using Natural and Synthetic Sorbents. Environmental Research, Engineering & Management, 43(1), 28-34.

How Do Brita Filters Work? (n.d.). Retrieved from

<https://www.brita.com/why-brita/health/how-do-brita-filters-work>

Morr, S., Cuartas, E., Alwattar, B., & Lane, J. M. (2006, March 29). How Much Calcium Is in Your Drinking Water? A Survey of Calcium Concentrations in Bottled and Tap Water and Their Significance for Medical Treatment and Drug Administration.

Retrieved from <https://link.springer.com/article/10.1007/s11420-006-9000-9>

References cont.

Reduction of Calcium Concentrations by the Brita® Water Filtration System: A Practical Experiment in Titrimetry and Atomic

Absorption Spectroscopy. (n.d.). Retrieved from <https://pubs.acs.org/doi/pdf/10.1021/ed078p941?download=true>

The Softening of Hard Water and Complexometric Titrations. An Undergraduate Experiment. (n.d.). Retrieved from

<https://pubs.acs.org/doi/pdf/10.1021/ed076p1420>

US7186344B2 - Membrane based fluid treatment systems. (n.d.). Retrieved from <https://patents.google.com/patent/US7186344B2/en>

V. (1997, January). Atomic Spectroscopy. Retrieved July 10, 2018, from <http://www.ufjf.br/baccan/files/2011/05/AAS-Varian1.pdf>

What Does Brita Filter Out? Chlorine & More. (2017, November 09). Retrieved from <https://www.brita.com/why-brita/what-we-filter/>

Acknowledgements

Allison, Nathan, Rose, and Philia would like to thank...

Professor Luis Avila for teaching us to operate the machinery as well as valuable life lessons.

Group Mentor Nadine Yassin for pushing us to work cohesively and assisting us whenever necessary.

The other group mentors and students for the moral support.

