MoDRN
Molecular Design Research Network

Project: Cleaners

Summary

For this project, students will evaluate the efficacy of several readily available cleaning solvents and the effect of these solvents on living organisms (i.e. plants)

Difficulty	Easy
Time required	2-4 weeks
Material Availability	Readily available
Cost	\$20-\$30
Safety	Supervision required due to use of toxic chemicals; gloves and goggles recommended
Green Chemistry Principle	1, 2, 8

The goal of this experiment is to evaluate the efficacy of several cleaners that are both manufactured and homemade as well as determine the impacts of these cleaners on the environment.

Background

Each year, millions of gallons of all-purpose cleaners are used and disposed of in households across the United States. While the efficacy of the cleaners for their respective purposes are important, it is also critical to consider the fate of the chemicals present once the use phase has ended. The labels of these cleaners often contain several hazard warnings due to the toxic nature of the materials. If you look up some of the ingredients on IRIS (a database managed by the EPA that contains toxic dose information for chemicals), the impact that these materials have on living species is clear.

To this end, several companies have manufactured “green” cleaning agents that claim to be as effective as their traditional counterparts, but come at a significantly higher cost. Are these “green” cleaners really safer and do they work as well as the cheaper alternatives?

Recently, there has also been a push to make your own cleaners at home. Many household items like baking soda and vinegar can be very effective cleaners, too.

In this experiment, you will evaluate how well each of these products work as well as their relative cost and environmental impact.

Materials

- 3 manufactured standard all-purpose cleaners (i.e. Formula 409, Lysol, Mr. Clean)
- 3 manufactured "green" all-purpose cleaners (i.e. method, Green Works, Seventh Generation)
- 3 homemade cleaners (sample recipes to follow)
  - ¼ c – ½ c vinegar; 2 T baking soda; tea tree oil (optional); water
  - ¼ c – ½ c vinegar; 2 T borox; tea tree oil (optional); water
  - Lemon juice; water
- 10 cups for growing plants, soil, and seeds I would suggest using some sort of bean (black eyed peas, faba bean). They grow really quickly (7 days) and don't need nutrients
- Water
- 2 small sheet of drywall
- Crayon/Marker
- Ketchup/Jam
- Syringe (without needle), dropper, or small measuring cup

Procedure

1. Place all plants where they can reach sunlight and ensure that they are equally healthy and viable.
2. Divide each sheet of drywall in half by drawing a vertical line down the middle. On each side, draw 11 equal sized squares and label each with the 9 cleaners; label 1 square with "water," and label the 11th square as "control."
3. On the first sheet of drywall, "soil" each of the 22 squares with crayon. Make sure to be consistent between squares.
4. On the second sheet of drywall, "soil" each of the 22 squares with the ketchup or jam.

The two sets of squares on each drywall sheet will be used to assess the efficacy of the cleaner on a "fresh" soiled stain and on a "dried" soil stain. Perform the following steps on half of the squares on each sheet of drywall a short time after soiling. Repeat these steps on the second half of the squares after 2 days.

5. While wearing the gloves and goggles, drop 1 mL of each cleaner onto each respective square, including water. The control square should remain as is.
6. Wait 1 hour and wipe the cleaner away with a paper towel and document the results using a camera. Assign a value between 1-10 for cleanser efficacy – 1 for the most effective cleanser and 10 for the least effective cleanser.
7. Repeat 5-6 for the "dried" half square after 2 days.
8. Average the two scores for each cleanser and record this value.

The second part of the experiment is to evaluate the impacts of each solution on a living organism.

9. Prepare the plants by filling each of 10 cups with some soil, planting a seed in each cups and covering it with more soil. Water and allow the plant to germinate until they reach about 4 inches in height.
10. Label each of the 10 cups with a cleanser name and the 10th cup with "water." Record the height of each plant in inches.
11. Once all the plants reach 4 inches in height, begin dosing 1 mL of cleanser per day in the total volume of water offered for 1 week. Make sure to give each plant the same amount of water.
12. After 1 week, record the height of each plant, number of leaves and leaf color
13.

The third part of the experiment is to evaluate the toxicity of the ingredients using IRIS (http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showSubstanceList).

14. For each of the 9 cleansers, find the ingredients label. Record the number of ingredients in each cleanser.
15. For each ingredient in the cleanser, search for the LD50/LC50 value on IRIS.
16. Average the LD50/LC50 values for the ingredients in each cleanser. Make sure to use consistent units (i.e. mg/kg)

The final part of the experiment is to quantify the cost of the cleanser, such that the per unit cost are comparable.

17. Record the price per bottle for each of the 9 cleansers and the volume of solution in each bottle.

Observations

1. From the four parts of the experiment, you should have data in the following form:

	Average cleanser efficacy (1-10)	Plant height (inches)	Number of ingredients (#)	Average LD50/LC50 values (i.e. mg/kg)	Cost per unit (i.e. $/mL)
#1					
#2					
…					
…					
…					
…					
#9					

2. We want to calculate a composite score for each cleanser based on all 5 categories…

[we want to scale the values so that each category has values between 1-10 (1 being the best). Then we take a weighted average based on a weight to each of the five categories, this weight is based on which are more important vs less important]

Variations

Instead of plants, use it collections of beans (20+) and sprout them in solutions containing each of the different cleansers. Survival rate after x number of days (never sprouted counts as dead) could be the quantitative dependent variable.