

# **Curing Humans but Injuring the Environment**

The detrimental effect of improper medication disposal to the environment

## **Question:**

Do medications negatively impact plant growth and survival, does the pH or type of medication exert a more significant effect on plant growth and survival, and are there any observable differences in plant growth and survival based on the type of medication applied?

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# Abstract

This study aims to evaluate the impact of the disposal of unused and expired medicines. Improperly disposed medicines could adversely affect the environment and increase the risk of drug misuse or accidental poisoning. Four experiments were conducted by growing Black Seeded Simpson lettuce and administering water (control), Tylenol (aq), Advil (aq), and Aspirin (aq) treatments. Statistical analysis was used to interpret data: SPSS program incorporating regression analysis and ANOVA. The statistical analysis revealed the negative effects of medication on plant growth. The extent of the impact on the plant varied based on medication type and quantity. The improper disposal of pharmaceutical products is unsafe for the environment, and there is a lack of awareness regarding the impact of improperly disposed medicines on the ecosystem. These findings emphasize the need to find strategies that can strengthen the pharmaceutical waste management program.



# Background Research

-“More than half of the patients surveyed reported storing unused and expired medications in their homes, and more than half had flushed them down a toilet. **Only 22.9% reported returning medication to a pharmacy for disposal. Less than 20% had ever been given advice about medication disposal by a healthcare provider.**” - *NIH*, “The Prevalence of Unused Medications in Homes”

-...less than 1% of people return unused medications to the pharmacy [15] and more than 50% flush them down the toilet [16] or in the trash [17]. ... unwanted drugs are commonly thrown in the garbage [18–21]. ... 82.1% of respondents threw unwanted drugs in the household garbage, 79.5% never received information about proper medication disposal practices, and 53.1% were unaware that unsafe medication disposal could harm the environment and population health. - *NIH*, “Safely disposing unused and unwanted prescription and over-the-counter medications: a public health, housing, and safety partnership in Framingham, MA”

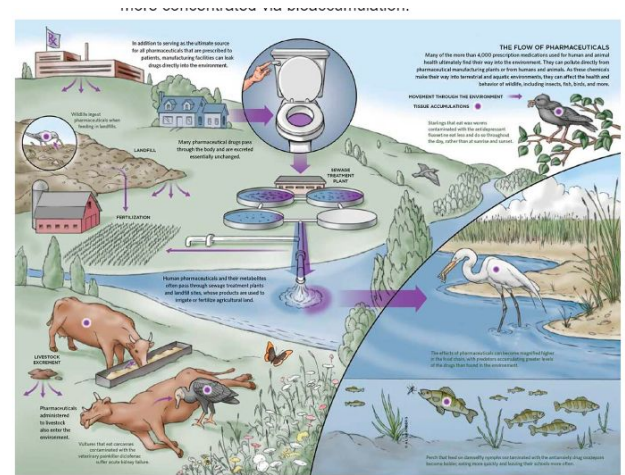


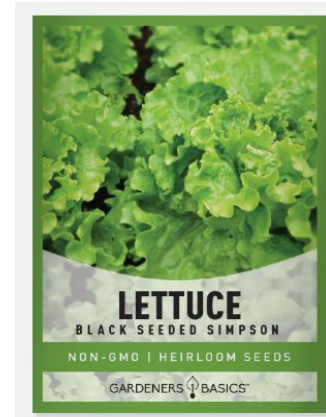
Figure 1. Reproduced from AI Granberg, originally from the article “Drugging the Environment” in *The Scientist*.

# Hypothesis

- 1a. The medication would negatively affect plant growth compared to water treatment.
- 1b. The medication would negatively affect plant survival compared to water treatment.
  
- 2a. A lower pH would negatively affect plant growth compared to a higher pH.
- 2b. A lower pH would negatively affect survival compared to a higher pH.
  
- 3a. The extent of the effect on plant growth would differ by medication type.
- 3b. The extent of the effect on plant survival would differ by medication type.
  
- 4a. The amount of medication administered would affect plant growth.
- 4b. The amount of medication administered would affect plant survival

# Materials per experiment

- 12 Recyclable pots (4")
- Miracle-Gro Moisture Control Potting Mix
- 3 Black Seeded Simpson lettuce seeds in each pot
- 4 Spray Bottles
- Tylenol for Adults Extra Strength-One caplet with Acetaminophen 500 mg
- Advil - One coated tablet with Ibuprofen 200 mg (NSAID)
- CVS Health Aspirin - Coated tablet with Aspirin 81 mg



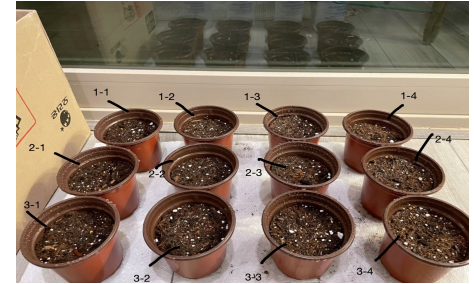
# Procedures

## Experiment Setup

1. Planted three Black Seeded Simpson lettuce seeds in plastic pots with Miracle-Gro Moisture Control Potting Mix.
2. Prepared 4 pots in following cases with total 12 pots.  
Treatment 1 (Water, label 1-x), Treatment 2 (labeled 2-x): Tylenol  
Treatment 3 (labeled 3-x): Advil  
Treatment 4 (labeled 4-x): Aspirin

## Experiment

1. Water 950. ml the following dosage were added  
Experiment 1.0( 3 dosages), Experiment 2.0: (2 dosages), Experiment 3.0  
→Experiment 3.0 – 1: 4 dosages  
→Experiment 3.0 – 2: 1 dosage
2. On day 1 of the experiment, the soil in each pot was sprayed with control or treatment liquid. The decision to vary the amount of treatment liquid sprayed per day was based on observations of soil saturation levels. Notably, though the amount of medication sprayed differed every day, all the treatments received the same number of sprays that were applied to every other treatment on that day. The experiment was conducted four times, with dosage variations for sensitivity analysis.



*Experiment setup*

Note : Experiment duration around 25 Days. Placed in front of large window.

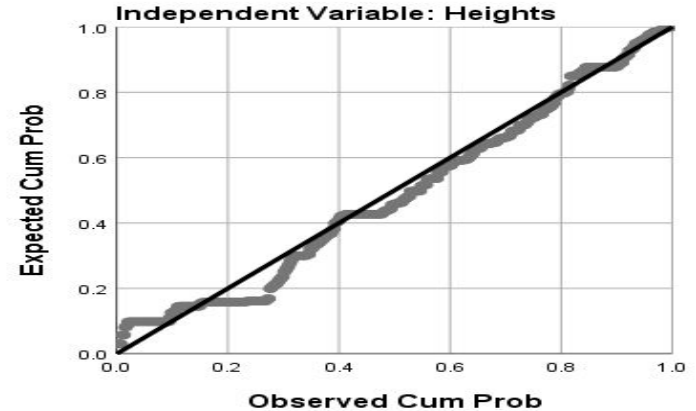
# Results - Data/Observations

Hypothesis verification results by research project

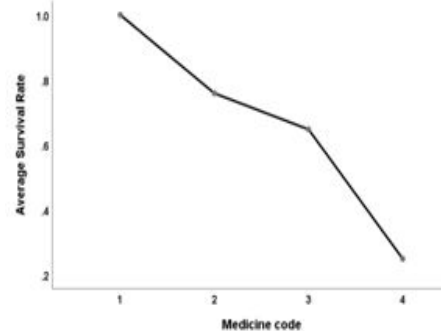
Drug dosage and pH level will have a significant effect on plant growth (height).	Results
H1 : negatively (–) affected based on the amount of medication administered.	Verified
H2 : Lower pH would have a more significantly negative (–) impact on survival compared to a higher pH.	Verified
<b>There will be differences in the effect on plant mortality depending on the type, dose, and pH level of the drug being discarded.</b>	
H3 : The extent of the effect on plant survival would differ by medication type. (Medicine code:: Water 1, Tylenol 2, Advil 3 Aspirin 4)	Verified
H 4 : The amount of medication administered would affect plant survival.	Verified
H5 : Lower pH would have a more significant negative impact on survival compared to a higher pH.	Verified

Hypothesis 1 and 2

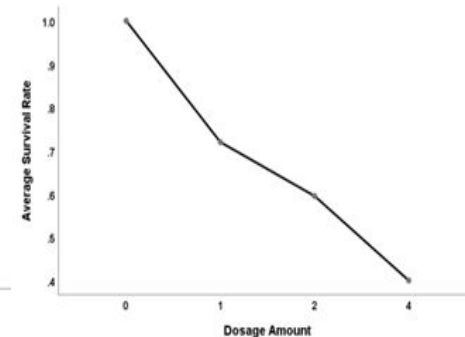
Normal P-P plot of regression standardized residual



Hypothesis 3



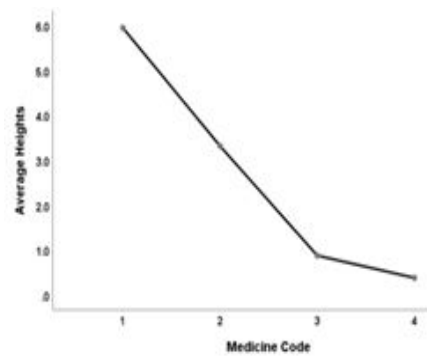
Hypothesis 4



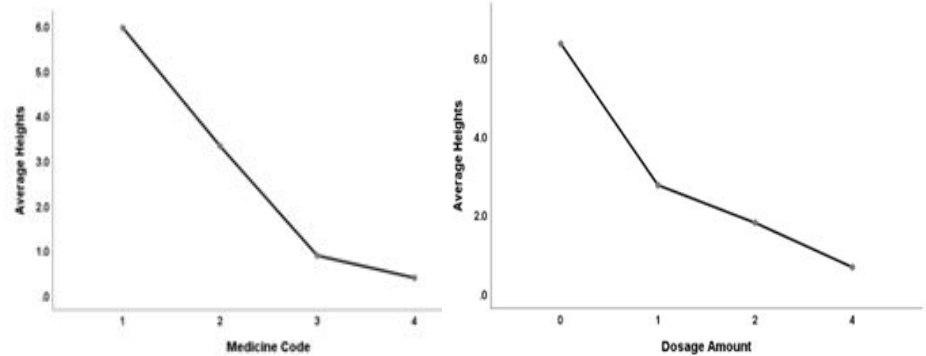
# Results - Data/Observations (Continued)

<p><b>The plant growth (height) will be affected depending on the type, dose, and pH level of the discarded drug</b></p>	<p><b>Verification results</b></p>
<p>Hypothesis 6 : The extent of the effect on plant growth would differ by medication type. <b>(Medicine code:: Water 1, Tylenol 2, Advil 3 Aspirin 4)</b></p>	<p>Verified</p>
<p>Hypothesis 7 : The amount of medication administered would affect plant growth.</p>	<p>Verified</p>
<p>Hypothesis 8 : Lower pH would have a more significant negative impact on plant growth compared to a higher pH.</p>	<p>Verified</p>

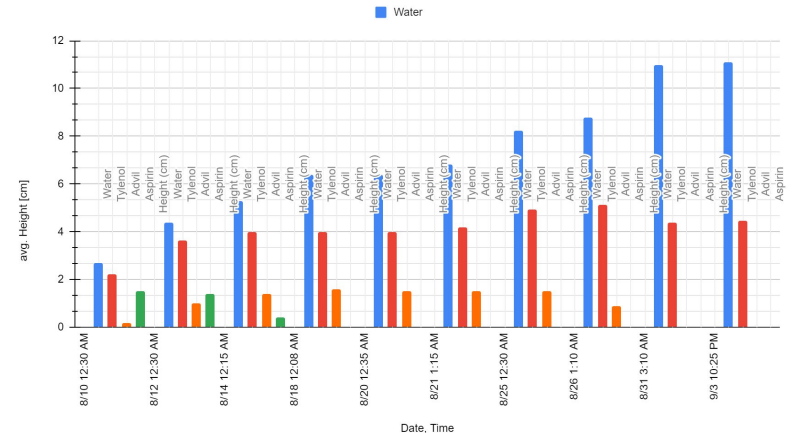
Hypothesis 6



Hypothesis 7



Average Height of Each Groups



**pH  
(from exp.  
2.0)**

8/5 9:40 PM	pH	Group 1	Group 2	Group 3
1	Water	8.3	8.3	8.3
2	Tylenol	7.7	7.7	7.7
3	Advil	6.8	6.8	6.8
4	Aspirin	5.3	5.3	5.3



# Discussion

- Plants grown with medication-dissolved water all showed less/slow height growth and increase in mortality
- Improperly disposed of medication, once it reaches the environment, will have a similar effect to the plants



This is the photo of 2~3 days after the end of experiment 2.0

Clear difference is shown in picture

# Discussion

- To reflect the disposal in the soil precisely, the color changed spray bottle of Tylenol was continuously applied.

## Limitations of this Study

These experiments did not take place in a controlled laboratory environment. There is a possibility of unaccounted confounding variables, such as the following:

- a. Temperature control was not perfectly maintained. (Experiment was not conducted at once
- b. The soil may have been unevenly mixed since a potting mix was used, making it impossible to ensure consistent compositions and multiple bags of the potting soil across all the treatments.
- c. Differences in the makeup of the potting mix used in different experiments because different bags of potting mix were used for experiments 1, 2, and 3, although the brand and type of potting mix were the same might.
- d. The sprout height was measured as the distance from the surface of the soil to the highest point of the sprout, regardless of whether it was the tip of the sprout or not. Therefore, sprouts that grew longer (in total length) may not have been recorded if they did not grow taller.
- e. The experiment measured the effect of medication treatments on vertical growth rather than on the total growth of the sprouts or the total biomass of the sprouts.

# Reflection/Application

- More awareness regarding the potential harm of improper medication disposal is needed
- Drug Disposal Guidelines should be more well known
- When developing drugs, pharmaceutical companies should consider the potential detrimental effects of medications

The infographic features a central red banner with the word "SAFE" in large white letters above "MEDICATION DISPOSAL" in white letters. Below this are four circular panels illustrating the disposal steps: 1. A blue bin labeled "SAFELY DISPOSE OF UNWANTED & EXPIRED MEDICINES". 2. A white container with coffee grounds, labeled "Mix with an unappealing substance." 3. A white container with a lid, labeled "Place in a sealed container." 4. A hand pouring the mixture into a trash bin, labeled "Throw into household trash." To the right of this panel is a purple box labeled "Scratch out personal information". At the bottom left is the Rockaid logo, and at the bottom center is the website "www.rockaidng.com".

## SAFE

MEDICATION DISPOSAL

1. Safely dispose of unwanted and expired medicines in a bin.
2. Mix with an unappealing substance.
3. Place in a sealed container.
4. Throw into household trash.

Scratch out personal information

www.rockaidng.com

## Drug Disposal Guidelines

If no disposal instructions are given on the prescription drug labeling and no prescription drug take-back program is available in your area, then follow these simple steps to throw the drugs in the household trash:

1. Remove the medicine from its original container and mix it with an undesirable substance, such as used coffee grounds or kitty litter.
2. Place the mixture in a sealable bag, empty bag, or other container to prevent medicine from leaking or breaking out of a garbage bag.

# References Cited

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