NSF-2025

SYNOPSIS OF PROJECT REPORT FORMAT

1. Project Details:

Project ID. NSF-SCH-2025-140

Project Title : **Soapy Showdown: How Cleansers Affect Plant Growth**

Participant Name : **S. MARYAM FATHIMA**

Name of School : AIM Nursery & Primary School.

Address of School /College : Alandur, Chennai.

City & State: Chennai, Tamil Nadu.

2. Introduction

This scientific project delves into a question: Can the water from our homes—often called "greywater"—be safely used to water plants? Greywater includes runoff from sinks, showers, and washing machines but excludes water from toilets.[1] To address this question, this project focuses on the two main components found in greywater that are of concern to plants: soaps and detergents.

A key purpose of this experiment is to act as a scientific detective, gathering evidence to understand if these substances are beneficial or harmful. This is a crucial distinction, as pollutants that flow down storm drains, even unseen ones like dissolved soaps, can directly enter and harm local wetlands, rivers, and streams.[2] It aims to determine if common household cleaning agents, when diluted and used for watering, have a positive, negative, or neutral impact on plant health and soil composition. The project serves as a practical exploration of environmental science concepts, linking household practices to broader ecological effects.

Although the terms "soap" and "detergent" are often used interchangeably in everyday language, they are chemically and functionally distinct.[3] A true soap is a natural product, typically derived from the process of saponification, which involves reacting vegetable oils or animal fats with a liquid alkali.[4] This structure allows soap to act as a "surfactant," a substance that reduces the surface tension of water, allowing it to mix with and lift away oils and grease.[4] In contrast, detergents are synthetic derivatives.[4] Detergents are materials which aid in the

removal of dirt or other foreign matters from contaminated surfaces.[7] They are the sodium salts of long-chain benzene sulfonic acids.[3] Soaps are generally biodegradable, Some detergents, particularly those with a branched hydrocarbon chain, are non-biodegradable.[4]

How soap and detergents affect Plants and Soil

The effect of soaps and detergents on plant life is not a simple matter of "good" or "bad." One potential benefit of using certain cleaning agents is their function as a "wetting agent".[5] The addition of a detergent can reduce the water's surface tension, allowing it to spread out and permeate the soil's pores, thus improving water penetration.[5] A major concern is that while detergents are excellent at dissolving oils and waxes, this can be detrimental to plants.[6] Plant leaves are naturally covered with a waxy cuticle that protects them from water loss, sun damage, and pathogens.[6] When a detergent is sprayed on a plant, it can strip this protective coating, leaving the plant vulnerable to disease and stress.[6]

We carried out the literature review to know the about the published studies. Ehilen et al. has investigated The effect of different detergents on seed germination and growth of Amaranthus hybridus L. and Solanum lycopersicon L.[7] The results of the germination studies revealed that the presence of the detergents in watering solution significantly reduced seed germination and radicle length.

According to the field project report done by Department of Environmental science, All Saints' College, Trivandrum, on the work Impact of detergent on plant growth 8, plants watered with high detergent concentration is unhealthy for plant growth and brings about unfavorable changes in soil physiochemistry.

When plants absorb the detergent contaminated water the ill effects may include inhibition of seed germination[9] effects like retardation of growth, inhibition of pollen germination and pollen tube growth, decrease in root length and decrease in overall growth activity. Surfactants may influence translocation of heavy metals from soil into plants [10].

The primary objectives of this scientific investigation are to:

1. Observe and document the growth and overall health of plants watered with clean tap water, a diluted soap solution, and a diluted detergent powder and detergent liquid solution.
2. Compare the growth metrics—such as plant height and leaf count—across the three different plants viz. tomato, green pea, and mung bean to identify any significant differences.
3. Based on the collected data, formulate a conclusion about the comparative effects of soap and detergent solutions on plant growth and soil health.

Based on the research background, the following testable predictions were made:

1. The plants watered with clean tap water (the control group) will exhibit the healthiest growth.
2. The diluted detergent solution will have a more negative impact on plant growth and overall health compared to the diluted soap solution.
3. Plants in the detergent group will display visible signs of stress or damage, such as wilting, yellowing, or leaf spots, at a faster rate than the plants in the soap group.

3. METHODS

Step 1: Labelling: Four identical pots with potting soil were clearly labelled as follows:

1. Normal water (Control),
2. Bathing Soap solution
3. Powder Detergent solution and
4. Liquid Detergent solution

Step 2: Potting: Plant seeds of 3 different plant groups *viz* tomato, green pea, and mung bean from the same source to ensure genetic consistency were seeded in each pot with the same amount of potting soil.

Step 3: Solution Preparation: The four watering solutions in separate, labelled containers.

- **Control Solution:** The 1st container was filled with 1 L of clean tap water with no additives.
- **Soap Solution:** In a 2nd container, 5% of soap solution was prepared by dissolving app. 5g of bathing soap into 1 L of clean water and mixed thoroughly.
- **Detergent powder solution:** In a 3rd container, 5% of Detergent powder solution was prepared by dissolving app. 5g of powder detergent into 1 L of clean water and mixed thoroughly in a separate utensil.

- **Detergent liquid solution:** Finally, in a 4th container, 5% of liquid detergent solution was prepared by dissolving app. 5g of detergent powder into 1 L of clean water and mixed thoroughly in a separate utensil.

Variables and Controls

- **Independent Variable:** The independent variable is the type of solution used for watering the plants. There will be 4 levels: clean water, a diluted soap solution, a diluted powder detergent solution and a liquid detergent solution.
- **Dependent Variables:** The dependent variables in this project include the plant's height (measured in centimeters), the number of leaves, and the overall qualitative health of the plant (e.g., color, wilting, appearance of spots).
- **Controlled Variables:**
  - Same type and amount of soil was used in each pot.
  - Same amount of water given to each plant at each watering.
  - The watering schedule - every day.
  - 4 types of plant used in this project.

4. RESULTS

Data Collection and Observations

Initially all the plants in the four pots were watered with clean water during the first 21 days to reach a certain growth. Afterwards the data collection and observations were made as follows;

1. **Watering:** Each pots were watered with its assigned solution on a consistent schedule.
2. **Quantitative Data:** Every day, the height of each plant was measured and the number of leaves on each plant were counted and recorded.
3. **Qualitative Data:** On a daily basis, any visually changes in leaf color, texture (e.g., spots, curls), or overall appearance were noted.

The following tables provides the results of the research work.

Table 1: Experimental Data for tomato plant

Day	Control		Soap solution		Powder Detergent solution		Liquid Detergent solution	
	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves
1	10	5	10	5	10	6	10.5	7
2	10.5	7	10.5	9	10.5	8	11	10
3	11.5	10	11.5	12	11.5	12	13	16.5
4	12.0	10	12.0	14	12.0	12	14	17
5	12.5	12	12.5	16	12.5	14	14.5	20
6	13	14	12.5	16	12.5	14	15	20
7	13.5	17	13.5	19	13.5	17	16	22

Note: *Day 1 refers to the first day of the data collection after the plants reached a certain height after 21 days of normal watering.*

Table 1a: Qualitative Observations for tomato plant

Day	Control	Soap solution	Powder Detergent solution	Liquid Detergent solution
1	Healthy	Healthy	Healthy	Healthy
2	Healthy	Healthy	Healthy	Healthy
3	Healthy	Healthy	Healthy	Healthy
4	Healthy	Healthy	Healthy	Healthy
5	Healthy	Healthy	Healthy	Healthy
6	Healthy	Healthy	Healthy	Healthy
6	Healthy	Healthy	Healthy	Healthy

Note: decolor, wilting, leaf spots – are considered unhealthy

Table 2: Experimental Data for Green pea plant

Day	Control		Soap solution		Powder Detergent solution		Liquid Detergent solution	
	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves
1	10	5	12	5	11.5	5	9.0	5
2	10.5	9	12.5	6	12.0	6	9.5	5
3	11	15	13.0	9	12.5	12	10.0	7
4	11.5	19	13.0	16	12.5	12	10.0	7
5	11.5	23	13.5	21	12.5	20	10.5	15
6	12.0	27	13.5	24	12.5	23+3dl	10.5	21
7	12.0	30	13.5	27	12.5	18+7dl	11.0	17+5dl

Note: *Day 1 refers to the first day of the data collection after the plants reached a certain height after 21 days of normal watering.*

**dl –dead leaves*

Table 2a: Qualitative Observations for Green pea plant

Day	Control	Soap solution	Powder Detergent solution	Liquid Detergent solution
1	Healthy	Healthy	Healthy	Healthy
2	Healthy	Healthy	Healthy	Healthy
3	Healthy	Healthy	Healthy	Healthy
4	Healthy	Healthy	Healthy	Healthy
5	Healthy	Healthy	Leaf spots, wilting	Wilting
6	Healthy	Healthy	Leaf spots, wilting	Wilting
7	Healthy	Leaf spots	Leaf spots, wilting, Shrivel	Wilting, decolor

Note: decolor, wilting, leaf spots, shrivel – are considered unhealthy

Table 3: Experimental Data for Mung bean plant

Day	Control		Soap solution		Powder Detergent solution		Liquid Detergent solution	
	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves	Height (cm)	No. of Leaves
1	23.0	6	23.0	8	22.0	8	25.5	6
2	24.0	8	23.5	8	23.0	8	27.0	6
3	25.0	8	24.0	8	24.0	8	28.0	8
4	26.0	8	24.0	8	24.5	8	28.5	8
5	26.0	8	24.5	8	25.0	8	28.5	8
6	26.5	7+2dl	24.5	6+2dl	25.0	9	29.0	8
7	26.5	7+2dl	24.5	6+2dl	25.0	10	29.0	8

Note: *Day 1 refers to the first day of the data collection after the plants reached a certain height after 21 days of normal watering., *dl –dead leaves*

Table 3a: Qualitative Observations for Mung bean plant

Day	Control	Soap solution	Powder Detergent solution	Liquid Detergent solution
1	Healthy	Healthy	Healthy	Healthy
2	Healthy	Healthy	Healthy	Healthy
3	Healthy	Healthy	Healthy	Healthy
4	Healthy	Healthy	Healthy	Healthy
5	Healthy	Healthy	Leaf spots, wilting	Wilting
6	Healthy	Healthy	Leaf spots, wilting	Wilting
7	Healthy	Leaf spots	Leaf spots, wilting,	Wilting, de-color

Note: decolor, wilting, leaf spots, shrivel – are considered unhealthy

5. DISCUSSIONS

This experiment observed the growth of three different plants (Tomato, Green Pea, and Mung Bean) over seven days, comparing a Control (clean water) to three detergent solutions: Soap, Powder Detergent, and Liquid Detergent. The results show varied effects of the detergent solutions on the growth of the different plant species.

1. Tomato Plant

- ***Quantitative Data (Table 1):***
  - Best Growth: The Liquid Detergent solution resulted in the best growth, with the greatest increase in both height (16 cm) and number of leaves (15 leaf increase).
  - Comparable Growth: The Soap and Powder Detergent solutions showed growth in height and leaves comparable to the Control group.

- ***Qualitative Data (Table 1a):***

- All tomato plants remained "Healthy" throughout the seven days of observation, indicating no visible negative effects like decoloration or wilting from any of the solutions.

2. Green Pea Plant

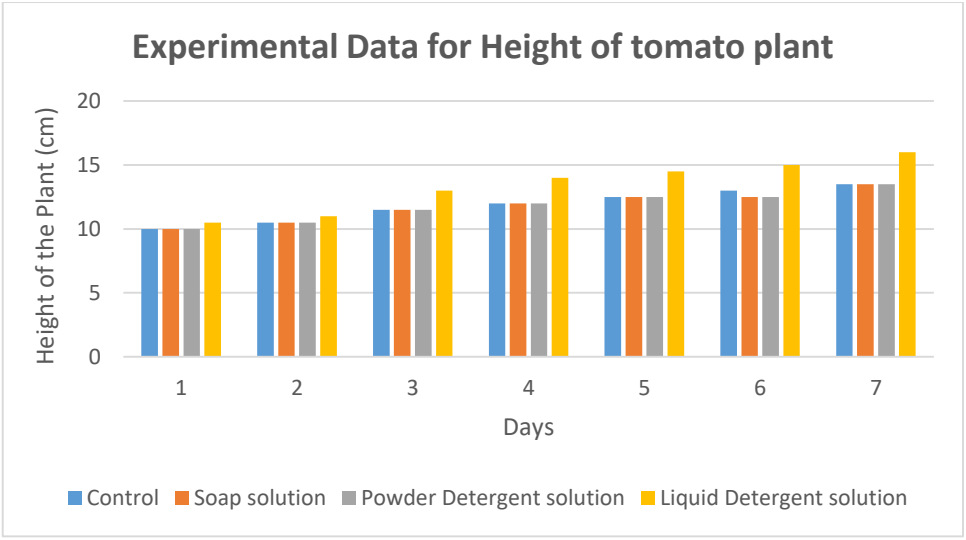
- ***Quantitative Data (Table 2):***
    - Best Growth: The Soap solution resulted in the greatest final height (13.5 cm and highest final leaf count (27 leaves) with no dead leaves until Day 7.
    - Worst Growth: The Liquid Detergent solution resulted in the smallest final height (11) and had 5 dead leaves by Day 7.
    - Negative Effects: The Powder Detergent and Liquid Detergent groups showed the presence of dead leaves (dl) by Day 6 and Day 7.

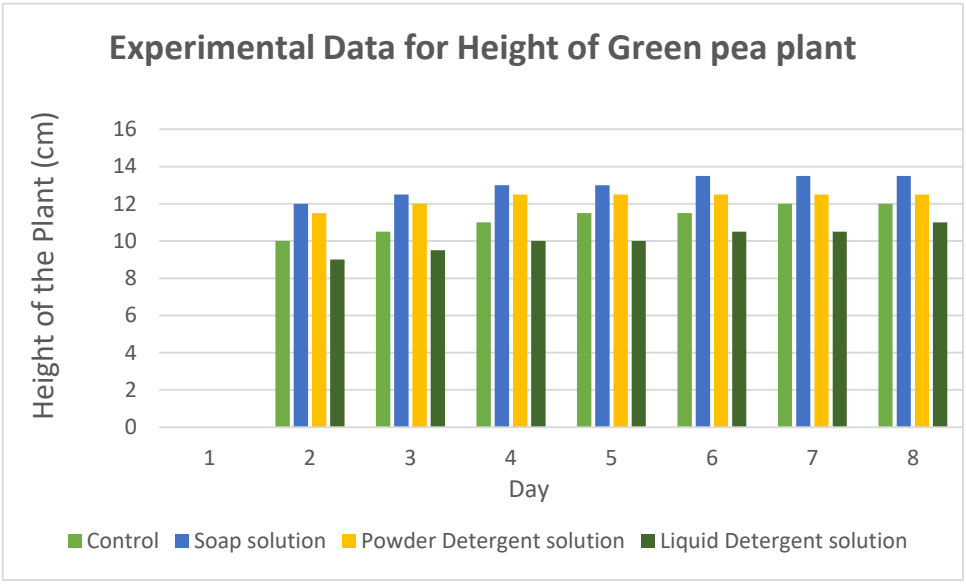
- ***Qualitative Data (Table 2a):***
    - Toxicity/Stress: Powder Detergent and Liquid Detergent solutions began showing signs of stress (wilting, leaf spots) by Day 5. By Day 7, all detergent groups showed signs of stress (leaf spots, wilting, shrivel, decolor), while the Control remained "Healthy".

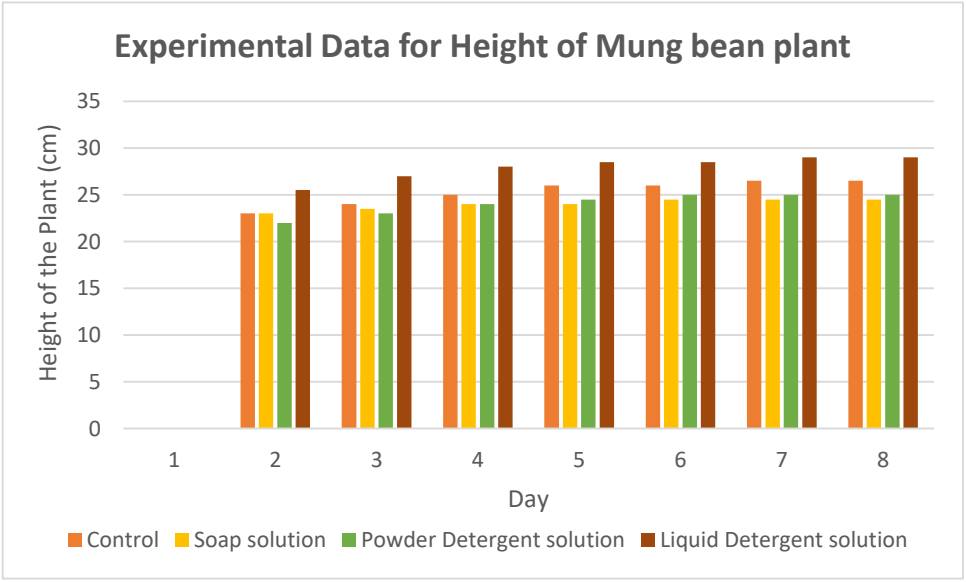
3. Mung Bean Plant

- ***Quantitative Data (Table 3):***
    - Best Growth: Liquid Detergent solution resulted in the greatest final height (29.0 cm).
    - Poorest Growth: The Soap solution resulted in the smallest final height (24.5 cm) and had 2 dead leaves (dl) by Day 6. Dead Leaves: The Control and Soap groups both showed the presence of dead leaves by Day 6.

- ***Qualitative Data (Table 3a)***
    - Toxicity/Stress: Similar to the green pea, the Powder Detergent and Liquid Detergent solutions began showing signs of stress (wilting, leaf spots) by Day 5. By Day 7, all detergent groups showed signs of stress, while the Control remained "Healthy".


Experimental Data for Height of tomato plant
Height of the Plant (cm)
20
15
10
5
0
1
2
3
4
5
6
7
Days
Control
Soap solution
Powder Detergent solution
Liquid Detergent solution


Experimental Data for Height of Green pea plant
Height of the Plant (cm)
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
Day
Control
Soap solution
Powder Detergent solution
Liquid Detergent solution


Experimental Data for Height of Mung bean plant
Height of the Plant (cm)
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
Day
Control
Soap solution
Powder Detergent solution
Liquid Detergent solution

Possible Reasons for the experimental data

1. Phytotoxicity of Surfactants and Alkalinity

Detergents primarily contain **surfactants** (the cleaning agents) and often have a high pH due to **alkaline builders** (like carbonates or silicates) can cause damage to cell membranes and interfere with the availability and uptake of essential soil nutrients causing stress symptoms as seen in the Green Pea and Mung Bean plants treated with Powder and Liquid Detergent solutions [11].

2. Species-Specific Sensitivity

The key difference in the results is that the **Tomato plant** was highly tolerant (even stimulated), while the **Green Pea** and **Mung Bean** plants were sensitive[12].

- **Differential Tolerance:** Different plant species have varied levels of tolerance to chemical stressors. The **Tomato plant** may possess a more robust cuticle (the waxy layer on leaves) or cell structure that made it highly resistant to the phytotoxic effects of the detergent solutions.

3. Nutrient Content in Liquid Detergent

The finding that the **Liquid Detergent solution stimulated growth** in the Tomato and Mung Bean plants' height suggests the presence of beneficial compounds.

- **Trace Nutrients:** Liquid detergents often contain minor ingredients like **phosphates** (a common builder) or other trace elements[13]. If the concentration of the detergent used was low, these elements could have acted as a **fertilizer supplement**, temporarily boosting growth metrics like height and leaf production.

Healthy plants Day 1

Unhealthy Green Pea plant

Unhealthy Mung Bean plant

Healthy Tomato plant

6. CONCLUSIONS

The experiment demonstrates that the effects of common household cleaning solutions on plant growth are species-specific and concentration-dependent (though concentration was not varied, the effects varied across plants).

1. **Tomato Plants were the most resilient:** All detergent solutions were tolerated by the tomato plant, with the Liquid Detergent solution actually appearing to stimulate growth without causing visible signs of toxicity within the 7-day observation period.
2. **Green Pea and Mung Bean Plants showed toxicity:** The Powder and Liquid Detergent solutions, and to a lesser extent the Soap solution, induced signs of stress (wilting, leaf spots, dead leaves) in the Green Pea and Mung Bean plants, especially from Day 5 onward, suggesting a phytotoxic effect.
3. **No single best solution:** No single solution was universally superior. For the tomato, liquid detergent was best; for the green pea, soap was best; and for the mung bean, liquid detergent was best in height but showed signs of wilting. The Control was the only treatment that maintained healthy qualitative observations across all three species.

*****

7. REFERENCES

1. Are Green Detergents Less Toxic Than Conventional Detergents ..., accessed on September 8, 2025, https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvSci_p053/environmental-science/are-green-detergents-less-toxic
2. 3rd Grade Unit “Pollution and Plant Growth”, accessed on September 8, 2025, https://www.eugene-or.gov/documentcenter/view/13791
3. byjus.com, accessed on September 8, 2025, https://byjus.com/chemistry/difference-between-soap-and-detergent/#:~:text=Soaps%20are%20the%20sodium%20salts,have%20a%20strong%20cleaning%20effect.
4. Difference Between Soap And Detergent - BYJU'S, accessed on September 8, 2025, https://byjus.com/chemistry/difference-between-soap-and-detergent/
5. Washing Detergent & Hydrophobic Soil | Science project - Education.com, accessed on September 8, 2025, https://www.education.com/science-fair/article/wetting-hydrophobic-soil/
6. Dish Soap Can Damage Your Plants - Don't use it. - Garden Myths, accessed on September 8, 2025, https://www.gardenmyths.com/dish-soap-damage-your-plants/
7. Ehilen, Oseghale & Obadoni, Bernard & Imade, Francis & D., Eseigbe & J.K, Mensah. (2017). The Effect of Detergents on the Germination and Growth of Amaranthus hybridus L. and Solanum lycopersicon L. Nigerian annals of Natural Sciences. 16. 100-108.
8. https://iqac.allsaintscollege.ac.in/proof/c1/1_3_2/field_projects/2020_2021/FIELDPROJECT_2.pdf

9. Heidari, H. (2013). Effect of Irrigation with Contaminated Water by Cloth Detergent on Seed Germination Traits and Early Growth of Sunflower (Helianthus annuus L.). Notulae Scientia Biologicae, 5(1), 86–89.
10. Pierattini, E., Di Piazza, S., Giordani, T., Pieraccini, G., Cozzi, F., & Gonnelli, C. (2017). Surfactant and heavy metal interaction in poplar: A focus on SDS and Zn uptake. Environmental Science and Pollution Research, 24(33), 25686–25697.
11. Uzma, S., Khan, S., Murad, W., & Azizullah. (2018). Phytotoxic effects of two commonly used laundry detergents on germination, growth, and biochemical characteristics of maize (Zea mays L.) seedlings. Environmental Monitoring and Assessment, 190(11), 666.
12. Ehilen, O. E., Obadoni, B. O., Imade, F. N., Eseigbe, D., & Mensah, J. K. (2017). The effect of detergents on the germination and growth of Amaranthus hybridus L. and Solanum lycopersicon L. Nigerian Annals of Natural Sciences, 16(1), 100-108.
13. Pathak, T., Bhardwaj, N., & Sharma, J. (2018). Effect of Dishwashing Detergent Baron Growth of Crop Plants. International Journal for Multidisciplinary Research, 6(4), 38-40.

Websites references:

- ScienceBuddies.org
- Eugene-OR.gov
- BYJU's.com
- SowRightSeeds.com
- Education.com
- GardenMyths.com
- YouTube.com

*****