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THE EFFECT OF DISH SOAP WASTEWATER ON THE GROWTH AND PHYSIOLOGICAL RESPONSE OF AQUATIC PLANTS

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Abstrak: Penelitian ini bertujuan untuk menyelidiki pengaruh air limbah sabun cuci piring terhadap pertumbuhan dan respons fisiologis tumbuhan akuatik. Desain kuantitatif kuasi-eksperimental digunakan, melibatkan tiga spesies tumbuhan: Ipomoea aquatica (kangkung air), Eichhornia crassipes (eceng gondok), dan Sansevieria trifasciata (lidah buaya). Setiap spesies terpapar larutan yang mengandung 16 g/L air limbah sabun cuci piring selama empat hari, dan perubahan pH, warna daun, dan biomassa diamati. Hasil penelitian menunjukkan bahwa Ipomoea aquatica mengalami stres paling parah, dengan penurunan pH air dan berat tanaman yang signifikan, sementara Epomoea crassipes menunjukkan toleransi sedang dan Spomoea trifasciata sebagian besar tidak terpengaruh. Temuan ini menunjukkan bahwa surfaktan dan fosfat dalam cairan pencuci piring dapat mengganggu fungsi fisiologis seperti penyerapan nutrisi dan fotosintesis. Penelitian ini menyoroti risiko ekologis limbah deterjen rumah tangga dan menyarankan bahwa tumbuhan resisten seperti Spomoea trifasciata dapat digunakan untuk fitoremediasi. Meningkatkan kesadaran publik dan mempromosikan produk pembersih ramah lingkungan sangat penting untuk mengurangi kontribusi rumah tangga terhadap pencemaran air.

Kata Kunci: Air Limbah Sabun Cuci Piring, Tumbuhan Air, Respons Fisiologis, Fitoremediasi, Pencemaran Lingkungan.

Abstract: *This study aimed to investigate the effect of dish soap wastewater on the growth and physiological responses of aquatic plants. A quasi-experimental quantitative design was used, involving three plant species: Ipomoea aquatica (water spinach), Eichhornia crassipes (water hyacinth), and Sansevieria trifasciata (snake plant). Each species was exposed to a solution containing 16 g/L of dish soap wastewater for four days, and changes in pH, leaf color, and biomass were observed. The results showed that I. aquatica experienced the most severe stress, with a notable decrease in water pH and plant weight, while E. crassipes showed moderate tolerance and S. trifasciata remained largely unaffected. These findings indicate that surfactants and phosphates in dishwashing liquids can disrupt physiological functions such as nutrient absorption and photosynthesis. The study highlights the ecological risk of household detergent waste and suggests that resistant plants like S. trifasciata could be used for*

phytoremediation. Raising public awareness and promoting eco-friendly cleaning products are essential to reduce household contributions to water pollution.
Keywords: *Dish Soap Wastewater, Aquatic Plants, Physiological Response, Phytoremediation, Environmental Pollution.*

INTRODUCTION

Water pollution has become one of the most pressing environmental problems in the modern era. Among the many sources of contamination, household wastewater particularly from dishwashing and cleaning products has received less attention compared to industrial waste. In most households, greywater containing detergent residues is directly discharged into drainage systems without any treatment. Over time, this wastewater enters natural aquatic ecosystems such as rivers, ponds, and wetlands, altering the chemical balance of the water and threatening aquatic life. Recent studies have shown that household dish soaps and detergents contain a variety of active substances, including surfactants, phosphates, and synthetic fragrances, which may be toxic to both aquatic organisms and plants (Schlappa et al., 2024a). Surfactants are the main components in dishwashing liquids. They work by lowering the surface tension of water, helping grease and dirt to dissolve. However, these same properties make them dangerous in aquatic environments because they can disrupt cell membranes, reduce dissolved oxygen, and change the pH of the surrounding water (Ríos et al., 2023). Emphasized that surfactants can also increase the mobility of microplastics and heavy metals in water, leading to further ecological stress. The toxic effects of surfactants depend on their concentration, composition, and the sensitivity of local organisms. Even at low concentrations, prolonged exposure can interfere with the photosynthetic efficiency and growth rate of aquatic plants (Mukherjee et al., 2024).

Aquatic plants play a crucial role in maintaining ecosystem balance. They absorb excess nutrients, provide oxygen, and serve as natural filters that improve water quality. However, when exposed to detergent wastewater, their physiological functions may be compromised. According to (Sharma et al., 2024), plants like *Eichhornia crassipes* (water hyacinth) and *Ipomoea aquatica* (water spinach) are particularly sensitive to chemical pollutants, showing early signs of stress through chlorosis, reduced biomass, and slower growth. Who reported that detergent residues can delay seed germination and alter enzymatic activity in young plants.

Such physiological disruptions not only reduce plant survival but also weaken the ecosystem's ability to self-purify. The use of detergents containing phosphates has also been linked to eutrophication a process where excess nutrients cause algal blooms that deplete oxygen in the water (Chen et al., 2022). When oxygen levels drop, aquatic plants and animals struggle to survive, leading to a chain reaction that destabilizes the ecosystem. Even biodegradable detergents, often marketed as environmentally friendly, can still release harmful residues that accumulate in sediments over time (Dar et al., 2022). These effects are particularly concerning in tropical regions, where small bodies of water serve as habitats for both aquatic plants and local communities that rely on them.

Several studies have explored the resilience of different aquatic species when exposed to detergent contamination. For example, (Raza et al., 2023) investigated the phytoremediation capacity of several aquatic and semi-aquatic plants and found that some species could partially absorb surfactants from the water, reducing chemical concentration levels. Similarly, (Hashmat et al., 2024) noted that the presence of aeration and certain plant species in constructed wetlands can mitigate the negative effects of surfactants by increasing oxygen availability and promoting microbial activity. Nonetheless, the effectiveness of such natural remediation processes depends heavily on plant type, pollutant concentration, and exposure duration. The chemical behavior of surfactants in aquatic systems is complex. Once released, these molecules can bind with organic matter or sediments, making them difficult to remove through natural degradation (Wang et al., 2023). In addition, surfactants often occur as mixtures rather than single compounds, leading to unpredictable interactions and sometimes synergistic toxicity (Raza et al., 2023) found that even diluted detergent solutions can alter soil and water microbial activity, indirectly affecting plant nutrient uptake. This means that detergent pollution doesn't just harm aquatic vegetation directly it also disrupts the entire microbial community that supports plant growth.

The toxicological impact of detergents extends beyond the visible symptoms of leaf yellowing or wilting. Microscopic observations reveal structural damage in plant tissues, such as cell wall deformation, chloroplast disorganization, and reduced stomatal density (Mukherjee et al., 2024). Over time, these physiological changes can lead to permanent growth inhibition. In another experiment, (Wahyu Lestari & Siregar, 2024) demonstrated that *Eichhornia crassipes* exposed to liquid soap wastewater experienced reduced biomass and chlorophyll content. Their results highlight that even short-term exposure to detergent wastewater can significantly alter plant metabolism and photosynthetic activity. Environmental researchers are increasingly concerned about the long-term accumulation of these compounds. Surfactants and phosphate-based detergents can persist in sediments for months, slowly leaching back into the water column. This persistent pollution threatens biodiversity, especially in stagnant waters such as ponds or ditches near residential areas. (Sathya et al., 2022) pointed out, conventional wastewater treatment systems are often unable to fully remove these compounds, leaving residues that continue to affect aquatic life. The lack of awareness among the public about the environmental impact of dishwashing liquids worsens the situation, as most people still view household wastewater as harmless.

There is growing interest in finding sustainable ways to reduce the ecological footprint of household detergents. (Schlappa et al., 2024) proposed developing eco-friendly dish soaps derived from recycled vegetable oils, which demonstrated lower toxicity in marine and freshwater environments. Similarly, (Khalidi-idrissi et al., 2023) reviewed advances in biological wastewater treatment and emphasized the potential of plant-based remediation systems as a low-cost, sustainable approach for developing countries. However, despite technological improvements, the root problem remains: public behavior and waste management practices have not caught up with environmental needs. In the context of environmental education, small-scale experiments that examine the effects of household detergents on aquatic plants can be a powerful tool for raising awareness. By directly observing how common cleaning products affect plant growth and water quality, students and communities can better understand the hidden consequences of daily activities. This approach is especially valuable in developing regions, where wastewater is often discharged without filtration or treatment.

From a biological perspective, not all plants respond equally to detergent exposure. Some species, such as *Sansevieria trifasciata* (snake plant), exhibit greater tolerance due to their thick leaves and specialized metabolism known as CAM (Crassulacean Acid Metabolism), which allows them to conserve water and maintain photosynthesis under stress conditions In contrast, plants like *Ipomoea aquatica* have thinner leaves and more delicate root systems, making them highly sensitive to changes in water chemistry. These differences in resilience provide valuable insight into how plant structure and physiology influence environmental tolerance. The complexity of detergent pollution also involves interactions between physical and biological processes. For instance, surfactants can alter water surface tension, making it harder for aquatic plants to maintain buoyancy or gas exchange. Furthermore, the foaming effect of detergents can block sunlight penetration, reducing the photosynthetic rate of submerged plants (Hashmat et al., 2024). When combined, these factors create a hostile environment that limits plant growth and disrupts ecological balance. Over time, the cumulative effect of even small amounts of detergent waste can significantly degrade aquatic habitats.

In addition to the biological effects, detergent contamination has socioeconomic implications. Communities that rely on aquatic plants for food, livestock feed, or traditional medicine are directly affected when plant populations decline. The degradation of these natural systems can also lead to reduced water quality and increased costs for water purification. Given this background, studying the effects of dish soap wastewater on aquatic plants is not only relevant scientifically but also socially and educationally important. It bridges the gap between everyday household activities and their broader ecological consequences. Furthermore, it supports the growing movement toward sustainable living and environmental stewardship. By understanding how common detergents impact plant physiology and growth, society can take small but meaningful steps toward reducing pollution and preserving freshwater ecosystems.

RESEARCH METHODS

This study used a quasi-experimental quantitative design to examine how dish soap wastewater influences the growth and physiological response of aquatic plants, specifically *Ipomoea aquatica* (water spinach), *Eichhornia crassipes* (water hyacinth), and *Sansevieria trifasciata* (snake plant). The design was chosen because it allows controlled observation without full randomization, which is often difficult in small-scale environmental experiments (Capili & Anastasi, 2025). A purposive sampling technique was applied to select healthy plants of similar size and weight to ensure experimental consistency (Ahmed, 2024). Each plant type was placed in a 1.5-liter container filled with 400 mL of water mixed with 16 g/L of Mama Lemon dish soap. The independent variable was the concentration of dish soap wastewater, while dependent variables included water pH, leaf color, and plant biomass key indicators of physiological stress in aquatic plants (Xing et al., 2023). The experiment lasted four days, during which daily measurements of pH, weight, and visual symptoms such as chlorosis and wilting were recorded following procedures. pH was measured using indicator strips, biomass was determined with a digital scale, and color changes were assessed visually under consistent lighting conditions. Data were analyzed descriptively, focusing on mean differences and observable trends rather than inferential generalization, as recommended by (Putra et al., 2023). All wastewater was neutralized before disposal to prevent secondary contamination, adhering to environmentally responsible research principles.

RESULTS AND DISCUSSION

The experiment showed that dish soap wastewater had varying effects on the growth and physiological responses of the three aquatic plants observed. After four days of exposure, all plants exhibited some level of physical and chemical change in their growing medium, but the magnitude differed depending on the species. The pH of the water decreased noticeably in the first two days, particularly in the container with *Ipomoea aquatica*, while *Eichhornia crassipes* and *Sansevieria trifasciata* maintained more stable pH values. This finding suggests that *I. aquatica* is more sensitive to chemical changes and less capable of buffering acidity caused by surfactants and phosphates in dish soap (Mukherjee et al., 2024).

a. *Ipomoea aquatica*

b. *Eichhornia crassipes*

c. *Sansevieria trifasciata*

Figure 1. Initial condition of *I. aquatica*, *E. crassipes*, and *S. trifasciata* before exposure to dish soap wastewater.

All plants appeared healthy with firm stems and green leaves, indicating uniform initial conditions across treatments. *I. aquatica* had long, thin stems with floating leaves, *E. crassipes* showed thick green petioles and buoyant roots, while *S. trifasciata* displayed upright succulent leaves typical of CAM plants. These baseline observations ensured that subsequent changes in color or mass were attributed to the effects of dish soap exposure rather than natural variation.

Plant Species	Initial pH	Final pH	Initial Weight (g)	Final Weight (g)	Weight Change (g)	Observation Notes
Ipomoea aquatica	6.0	4.0	23	19	-4	Leaves turned yellow and wilted by day 3.
Eichhornia crassipes	6.0	6.0	57	55	-2	Slight leaf discoloration, still floating well.
Sansevieria trifasciata	6.0	6.5	120	118	-2	No major changes, leaves remained green & firm.

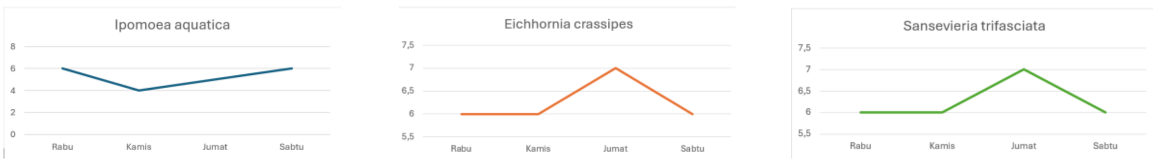
Table 1. Changes in Water pH and Plant Biomass After Four Days of Exposure

As seen in Table 1, *I. aquatica* experienced the most significant reduction in biomass (–4 g) and acidity shift (pH 6 to 4). This pattern aligns with the findings of Hernández-Baranda (2023), who noted that detergent exposure often leads to chlorosis and weight loss in aquatic species due to disrupted nutrient uptake and reduced photosynthetic activity. The surfactants present in the dish soap likely interfered with the permeability of plant cell membranes, increasing water loss and nutrient imbalance (Ríos et al., 2023). In contrast, *E. crassipes* showed moderate resistance, maintaining buoyancy and relatively stable pH conditions. Its spongy tissues might have acted as a physical barrier, absorbing and temporarily trapping surfactant molecules.

a. *Ipomoea aquatica* b. *Eichhornia crassipes* c. *Sansevieria trifasciata*

Figure 2. Physical appearance of *I. aquatica*, *E. crassipes*, and *S. trifasciata* after four days of exposure to dish soap wastewater.

Water spinach exhibited severe wilting and discoloration, while water hyacinth and snake plant showed minor or no visible damage. The difference in visual response highlights how plant structure influences tolerance to chemical stress. The results collectively indicate that dish soap wastewater can cause measurable physiological stress, especially in softer, more water-dependent plants like *I. aquatica*. The reduction in pH observed in the first two days may have triggered stomatal closure and decreased nutrient absorption efficiency, leading to wilting and tissue darkening (Xing et al., 2023). Meanwhile, the stability of *E. crassipes* and *S. trifasciata* suggests that plant morphology plays a crucial role in determining resistance to chemical pollutants.



a. *Ipomoea aquatica* b. *Eichhornia crassipes* c. *Sansevieria trifasciata*

Figure 3. Changes in water pH during four days of exposure for *I. aquatica*, *E. crassipes*, and *S. trifasciata*.

The pH of *I. aquatica* dropped sharply to 4 on day 2, while the other species maintained near-neutral levels, indicating stronger buffering capacity in *E. crassipes* and *S. trifasciata*.

Interestingly, *S. trifasciata* demonstrated the highest tolerance to the detergent solution. Despite a small reduction in weight, its leaves remained firm and green throughout the four-day period, who explained that plants with CAM metabolism can survive under environmental stress due to efficient water regulation and gas exchange control. The minimal change in pH around *S. trifasciata* also indicates a limited chemical interaction between the detergent and plant root environment. These findings are consistent with previous research showing that surfactant-based pollutants disrupt photosynthesis, oxygen exchange, and osmotic balance in aquatic plants (Chen et al., 2022). While short-term exposure might not kill the plants outright, long-term accumulation of such substances can alter microbial activity in water and reduce overall ecosystem productivity (Raza et al., 2023).The study highlights how even low concentrations of household detergents can alter water chemistry and plant physiology in subtle but significant ways.

In conclusion, the data demonstrate that dish soap wastewater negatively affects aquatic plants to varying degrees, depending on their structural and metabolic adaptations. *I. aquatica* is the most vulnerable, while *S. trifasciata* shows strong resistance. These results emphasize the importance of responsible household waste management and suggest that further studies should explore longer exposure durations, varying concentrations, and the potential of using resistant species for phytoremediation in detergent-contaminated environments.

CONCLUSION AND SUGGESTIONS

Conclusion

This study found that dish soap wastewater has a clear negative impact on aquatic plants. *Ipomoea aquatica* showed the highest sensitivity, with reduced biomass, leaf discoloration, and a drop in water pH, while *Eichhornia crassipes* displayed moderate tolerance and *Sansevieria trifasciata* remained the most resistant. These results indicate that the surfactants and phosphates in dishwashing liquids can disrupt plant physiology by affecting nutrient uptake and photosynthesis. The findings highlight the importance of managing household wastewater responsibly and suggest that tolerant species like *S. trifasciata* could be used for phytoremediation in detergent-contaminated environments. Overall, this research emphasizes that even small amounts of domestic waste can have significant ecological effects and should be addressed through greater environmental awareness and sustainable practices.

Suggestions

Future studies should investigate the long-term effects of dish soap wastewater using different concentrations and exposure durations to better understand its ecological impact. It is also recommended to include more aquatic and semi-aquatic plant species to identify those with strong tolerance for potential use in phytoremediation. On a practical level, communities should be encouraged to dispose of household wastewater more responsibly and reduce the use of chemical-based detergents. Developing and promoting eco-friendly dishwashing products can also help minimize environmental pollution and protect freshwater ecosystems.

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