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The Effect of Laundry Wastewater on the Photosynthetic Pigment (Chlorophyll A, B and Carotene

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ABSTRACT

The impact of laundry wastewater on the photosynthetic pigment levels (Chlorophyll a, b, and carotene) of 12-day-old watermelon seedlings was investigated in this study, focusing specifically on total carotene and total chlorophyll. Laundry wastewater, defined as water containing both inorganic and organic materials such as sweat washed off from clothing, was obtained from a local laundry facility. Various concentrations of laundry wastewater (including a control group and concentrations of 20ml, 40ml, 60ml, 80ml, and 100ml) were collected and mixed with 1600g of soil. Following the mixing of laundry wastewater with the soil, watermelon seeds were planted, and after 12 days, the photosynthetic pigment content was analyzed. The results revealed an initial increase in watermelon seed concentration up to a certain point, followed by a decrease at 60ml of laundry wastewater compared to 40ml. At 100ml concentration, no germination was observed, indicating the detrimental effects of detergent contamination on plant growth, particularly at high concentrations of laundry wastewater. It was noted that the impact of laundry wastewater on plants may vary depending on its management practices.

INTRODUCTION

Household products serve as significant contributors to the presence of harmful organic pollutants in the environment (Ivanković and Jasna, 2010). Disposal of waste and discharge of household products like detergents and cleaners result in their widespread dispersion, posing a threat to ecosystems (Ivanković and Jasna, 2010). Persistent organic pollutants, in particular, present a substantial risk to soil, where they form stable bonds with organic matter, leading to potential harm to crops, water quality, and human health (Rodríguez-Amaya, 2008). Soil pollution, often referred to as a "hidden danger," raises global concerns due to its challenging detection and assessment (Rodríguez-Amaya, 2008). Understanding the sources and characteristics of pollutants is crucial for effective pollution prevention, which can significantly reduce both financial and economic burdens (Environmental Protection Agency, 2019).

Previous studies, such as a 2018 investigation on the impact of laundry wastewater on soil properties and a 2020 examination of synthetic detergent's effect on soil erosion resistance, have explored the consequences of detergent pollution on soil (Mohamed, 2018; Chuchkalov et al., 2020). These studies have focused on assessing the environmental effects of both traditional and environmentally friendly detergents. As part of pollution prevention strategies for households and schools, the Environmental Protection Agency recommends transitioning to "green" cleaners, considering that detergent products contribute to approximately 10% of organic matter in domestic wastewater (Steber et al., 2011; Eivazi et al., 2018). It's worth noting that any toxic soil pollutant, including detergent ingredients, can directly impact soil microorganisms (Rodríguez-Eugenio, 2018). While phosphate detergents have historically been associated with eutrophication, regulatory measures prohibiting phosphate usage have prompted companies to switch to surfactant detergents, which still possess potential toxic effects due to their surface-active properties (Steber et al., 2011). Furthermore, previous research has indicated that surfactants, particularly alcohol ethoxylate found in conventional detergents, can inhibit soil enzyme activity and nutrient cycling (Eivazi et al., 2018).

Household detergents harbor surfactants that carry the potential to disrupt microbial activity and impede biogeochemical cycles. Research suggests that surfactants have the capacity to hinder enzyme function, inhibit plant growth, and modify soil's physical characteristics. Despite the evident threat posed by detergent pollution to ecosystems, comprehensive studies examining its impacts remain limited.

METHODOLOGY

Collection of sample

Watermelon was purchased at Oghara market, and its seeds were collected and left to dry. Loamy soil was sourced from a fallow area within the botanical garden of Delta State Polytechnic Otefe, Oghara, then air-dried and passed through a sieve with a $1mm^2$ mesh.

Planting procedure

The loamy soil obtained for the experiment exhibited several impurities, including dirt particles, stones, dead leaves, and grass roots. To ensure the soil's suitability for the experiment, it underwent a meticulous sieving process using a mesh with a $1mm^2$ aperture size. Subsequently, precisely 1600 grams of the sieved soil samples were meticulously mixed with varying concentrations of laundry wastewater, including a control group with clean water and five experimental groups with 20ml, 40ml, 60ml, 80ml, and 100ml of laundry wastewater, respectively. Each mixture was thoroughly blended to ensure uniform distribution of the wastewater throughout the soil.

Following the preparation of the soil-wastewater mixtures, four watermelon seeds were carefully planted in each container corresponding to the different concentration levels. The containers were labeled accordingly to denote the concentration of wastewater used in each. Throughout the experimental period, which spanned 12 days, the soil was diligently watered on a daily basis to simulate regular irrigation conditions.

Upon completion of the 12-day period, the leaves were methodically removed from the stems of the watermelon plants in each container, allowing for further analysis. Additionally, the soil in which the watermelon seeds were initially planted was discarded to prevent any potential contamination or interference with subsequent experiments. This meticulous approach ensured the reliability and accuracy of the experimental results.

Determination of photosynthetic pigments

(Chlorophyll a, b and Total carotene)

The chlorophyll content was determined following the method outlined by Lichtenthaler (1987), while the carotene content was estimated using the formula provided by Duxbury and Yentsch (1956). To begin, leaves weighing 0.2g were homogenized using a mortar and pestle in 10ml of 96% methanol. The resulting homogenate underwent filtration through a two-layered cheesecloth and was subsequently centrifuged at 2500rpm for ten minutes. The supernatant obtained after centrifugation was carefully transferred into a cuvette, and the absorbance was measured. Maximum absorbance readings were recorded at 666nm for chlorophyll a, 653nm for chlorophyll b, and 470nm for total carotene.

Calculation

The amounts of these pigments were calculated according to the formula of Lichtenthaler and Welburn, (1985).

Chlorophyll a (C_a) = $15.65A_{666} – 7.340A_{653}$

Chlorophyll b (C_b) = $27.05A_{653} – 11.21A_{666}$

Total Carotene (C_x + c) = $1000A_{470} – 2.270C_a – 81.4C_b/227$

RESULT

CONCENTRATION OF LAUNDRY WASTEWATER IN SOIL(ml)	Total CAROTENE470 (Ng/g)	TOTAL CHLOROPHYLL (Ng/g)
Control (0ml)	0.3 ± 0.3	4.4 ± 0.6
20ml	0.5 ± 0.4	4.8 ± 0.8
40ml	1.2 ± 0.9	12.6 ± 0.3
60ml	0.6 ± 0.2	8.1 ± 0.2
80ml	0.1 ± 0.4	3.0 ± 0.1
100ml	-----	-----

DISCUSSION

The analysis revealed a noteworthy trend concerning the impact of laundry wastewater concentration on the levels of total carotene and total chlorophyll in 12-day-old watermelon seedlings. Initially, there was an increase in both carotene and chlorophyll concentrations with the rising concentration of laundry wastewater in the soil, reaching a peak before subsequently declining at the 60ml concentration mark. Comparing the concentrations of total carotene in watermelon seedlings grown in laundry wastewater-amended soil to those in the control group, it was evident that there was a considerable increase. For instance, the control group yielded a total carotene concentration of 0.3 ± 0.3 Ng/g, while the group treated with 20ml of laundry wastewater exhibited a concentration of 0.5 ± 0.4 Ng/g, indicating an increase relative to the control.

Similarly, as the concentration of laundry wastewater increased to 40ml, the total carotene concentration in the watermelon seedlings rose to 1.2 ± 0.9 Ng/g, demonstrating a significant increase compared to both the control and the 20ml concentration. However, at 60ml of wastewater concentration, the total carotene concentration decreased notably to 0.6 ± 0.2 Ng/g, indicating a significant decline compared to the 40ml concentration. Further increases in wastewater concentration to 80ml resulted in a decrease in total carotene concentration to 0.1 ± 0.4 Ng/g, showing a decline relative to the control, 20ml, 40ml, and 60ml concentrations. Notably, at the highest concentration of 100ml, watermelon seedling germination was inhibited, indicating the detrimental effects of detergent-rich wastewater on plant growth.

Similarly, for total chlorophyll concentrations, a comparable pattern emerged, with increases observed with rising laundry wastewater concentrations up to 40ml. For instance, the control group exhibited a total chlorophyll concentration of 4.4 ± 0.6 Ng/g, while the 20ml wastewater-treated group showed an increase to 4.8 ± 0.8 Ng/g. At 40ml, the concentration rose significantly to 12.6 ± 0.3 Ng/g, showing an increase relative to both the control and the 20ml group. However, at 60ml, a significant decrease in total chlorophyll concentration to 8.1 ± 0.2 Ng/g was observed compared to the 40ml concentration. Further increases in wastewater concentration to 80ml resulted in a decrease in total chlorophyll concentration to 3.0 ± 0.1 Ng/g, indicating a decline relative to the 20ml, 40ml, and 60ml concentrations. At the highest concentration of 100ml, watermelon seedling growth was inhibited, underscoring the harmful effects of high concentrations of laundry wastewater on plant growth.

The results suggest that laundry wastewater may have a varying impact on 12-day-old watermelon seedlings depending on the concentration level in the soil. While lower concentrations showed potential positive effects on plant growth, higher concentrations were found to be detrimental. The study also highlights the potential benefits of employing combined anaerobic and aerobic processes for wastewater treatment to enhance resource recovery and treatment efficiency. However, it also underscores the need for caution due to the presence of toxic, non-biodegradable substances in some laundry wastewater, which may necessitate advanced oxidation processes to improve biodegradability and deactivate harmful microorganisms. Additionally, synthetic detergents containing volatile chemicals and substances like sodium chloride, bleach, and boron were identified as potential contributors to adverse effects on plant growth, emphasizing the importance of understanding and mitigating the impact of laundry wastewater on agricultural systems.

CONCLUSION

The influence of laundry wastewater on the total carotene and total chlorophyll levels of 12-day-old watermelon seedlings varies depending on the concentration of the wastewater in the soil. Lower concentrations of laundry wastewater have been observed to positively affect the photosynthetic pigment levels, leading to an increase. However, exposure to high concentrations of laundry wastewater has been found to negatively impact the photosynthetic pigment levels and hinder the normal growth of plants, likely due to the elevated concentration of pollutants present in the wastewater.

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