Entry to the Stockholm Junior Water Prize 2024

Reuse of Inked Water with Homemade Filtration to Produce Veggie Gardens

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Abstract

We conducted a diagnosis of the community issues in Teotitlán del Valle, focusing primarily on the scarcity of water for productive activities. The principal economic activity, rug production, utilizes clean water for dyeing with both natural and synthetic dyes, leading to the disposal of untreated inked water. Employing the Logical Framework approach, we proposed the development of a home filter to facilitate the reuse of inked water in vegetable cultivation. This project entails the evaluation of filtered water samples from homemade filters designed specifically for natural and synthetic dyes. Through experimental and observational assessments, we measured pH levels and coloration before and after filtration, noting variations with pH values ranging from 7 to 8. The filtered water was subsequently used for the germination of spinach and radish seeds, with further experimentation planned for other appropriate vegetables. The objective of this project is to establish a sustainable system that enhances family economies and nutrition, contributes to environmental conservation, and provides a viable water reuse strategy for the community.

Keywords

Community-Based Solutions; Water Scarcity; Circular Water Economy; Homemade Filters.

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We are particularly grateful to our project advisor, Ing. Brenda Jarquín Martínez, for her invaluable guidance, expertise, and encouragement throughout the development and execution of this project. Her support has been instrumental in achieving our objectives and contributing to the sustainable development of our community.

We are deeply thankful to all our teachers for their guidance and support. Moreover, we are grateful to our families for their unwavering encouragement throughout this journey.

Biographies

My name is **Shanni Valeria Mora Fajardo.** I am originally from Coatzacoalcos, Veracruz, but I have been living in Tlacolula de Matamoros, Oaxaca for several years. Currently, I am 16 years old and attend to the Bachillerato Integral Comunitario N° 29 in Teotitlán del Valle. I am deeply interested in preserving water security in Mexico and around the world. Additionally, I have a strong passion for learning about the diverse cultures of Oaxaca.

My name is **Rosa Mendoza Sosa**, and I am currently a student in the 4th module at Bachillerato Integral Comunitario N° 29. I was born and raised in Teotitlán del Valle, and I am 17 years old. As I embark on this new chapter, I eagerly anticipate the support of all artisans within our community.

Introduction

"It is commonplace, but no less true: water is a source of life and culture; practically any ecological process and undoubtedly in any civilization requires it" (López & Consejo, 2011, p. 23).

Water scarcity and pollution have been visualized as critical challenges facing our world today. "In Oaxaca, as in many parts of the planet, the water panorama shows a dramatic condition: more and more people without access to clean water, catastrophic floods, pollution" (Institute of Nature and Society of Oaxaca, 2014, p. 21).

In line with the findings from the community diagnosis conducted for the February-July 2023 school year, "water scarcity for productive activities" was identified as a priority issue within the economic axis. The community of Teotitlán del Valle primarily engages in wool textile production, specifically rug making, as highlighted in the Municipal Development Plan 2011-2013 and reaffirmed by the community diagnosis results. The dyeing of textiles requires a significant amount of clean water, leaving limited water availability for agricultural activities, which are crucial for food production. This issue is exacerbated by the overall scarcity of water in the community.

Due to the use of water in dyeing wool textiles, people in Teotitlán del Valle utilize products such as natural dyes, including cochineal, indigo, marigold flower, charcoal, walnut, and pomegranate. To achieve different shades, they often add drops of lemon and lime. Some families also use synthetic dyes, primarily based on aniline, along with acetic and sulfuric acid. Both types of inked water are not reused, and disposal into the drainage system is prohibited, particularly for water containing synthetic dyes. This untreated inked water reaches the wastewater treatment plant and adversely affects the surrounding vegetation. Consequently, inked water from textile dyes is often discarded in household patios. Given the increasing demand for water, we have become interested in reusing inked water, provided it is managed appropriately. We must explore alternative, sustainable uses for this resource.

Rosegrant *et al.* (2002), in the document "Global Water Outlook to 2025," highlight that the demand for water—an increasingly scarce global resource—is growing rapidly. This rising demand jeopardizes water availability for food production, posing a significant risk to global food security. Agriculture, which sustains the livelihoods of a growing population, competes for this limited water supply alongside industrial, domestic, and environmental uses. As demand from all sectors increases, groundwater reserves are depleted, aquatic ecosystems become polluted and degraded, and the development of new water sources becomes increasingly costly (p. 1).

Due to the limited and often insufficient supply of fresh water to meet the growing demands of communities, we conducted documentary research which identified that homemade filters can effectively remove impurities from water. As noted by Romero-Litvin (n.d.), these filters function by eliminating sediments, pathogens, and other contaminants. They are easy to construct and can be made using local materials.

Given these considerations, the project "Reuse of Inked Water with Homemade Filtration to Produce Veggie Gardens" was initiated. We believe this approach will enhance water conservation and reuse, contributing to biodiversity preservation and the maintenance of healthy ecosystems. Conventional treatment systems for water with impurities, such as inked water, can be prohibitively expensive due to the required infrastructure and specialized equipment. In contrast, constructing a home filter is simple, efficient, and cost-effective, offering an accessible solution for communities and households, particularly in regions with limited financial resources and water availability for agricultural activities.

In the community of Teotitlán del Valle, where most water is used for dyeing wool textiles, this project addresses immediate water needs and prepares communities for future challenges related to climate change, water scarcity, and food production. By reactivating the family or community economy and ensuring food availability, we lay the foundation for a sustainable and resilient future for the next generations, aligning with the 2030 Agenda for Sustainable Development.

Main problem

In recent years, drought has affected up to 70% of Mexican territory, significantly impacting water availability nationwide (IMTA, 2021). A stark illustration can be seen in Teotitlán del Valle, Oaxaca, where as of March 2024, the Piedra Azul irrigation unit, crucial for the municipality's agricultural supply, is reported to have only 30% of its capacity remaining (EFE, 204). This situation underscores the pressing need to enhance water management across all productive activities.

Teotitlán del Valle has an approximate population of 6,161 inhabitants, of which 94% describe themselves as indigenous population and 63% speak an indigenous language. 75% of the population lives in poverty, a figure significantly higher than the state average. Furthermore, only 15% of the population has access to a nutritious diet. (Secretariat of Welfare, 2024).

One of the primary economic activities in the municipality is the production of artisanal textiles, particularly rugs, featuring traditional Zapotec designs. This craft employs various natural dyes such as indigo for blue hues and cochineal for red tones, alongside synthetic alternatives. Water serves as a critical resource in this process. Unfortunately, once used, water is often discarded by artisans, diminishing its availability for other essential purposes.

A community diagnosis conducted by Bachillerato Integral Comunitario No. 29 from February to July 2023 highlighted a critical local issue: water scarcity severely hampers agricultural productivity. To address this challenge, adopting a circular economy approach to water is essential. This includes treating wastewater from textile production to recycle it for use in agriculture, thereby conserving this vital resource and supporting sustainable economic activities in the region.

Objectives

Main:

Assess the feasibility of using inked water samples filtered through a homemade system to support vegetable cultivation, emphasizing community-based solutions identified through comprehensive diagnosis and implementation.

Specific:

- Recognize the importance of constructing a water filter for reusing water dyed with natural and synthetic dyes in vegetable cultivation at the Community High School of Teotitlán del Valle.
- Construct a homemade filter using locally available materials to assess its efficacy in purifying water contaminated with natural and synthetic dyes.
- Utilize the homemade filter as a tool to remove impurities from water tainted with natural and synthetic dyes, offering an alternative for water reuse in vegetable cultivation and addressing water scarcity in the community of Teotitlán del Valle.
- Experimentally, determine the viability of reusing water filtered through the homemade system in vegetable cultivation, demonstrating its practical application and benefits.

Methodology

We present a detailed methodology aimed at addressing the pressing issue of water scarcity in vegetable cultivation through the reuse of inked water in Teotitlán del Valle, Oaxaca. The project is being carried out in the facilities of the educational campus of Bachillerato Integral Comunitario N° 29.

- The documentary stage involved obtaining information about homemade filters, including the types of materials used, the stages of obtaining samples, and the process for collecting water to be filtered.
- During the field phase, we constructed two homemade filters: one for filtering water dyed with natural dyes and another for water dyed with synthetic dyes.
- Additionally, an experimental and observational phase was conducted, which involved collecting natural and synthetic inked water. pH levels of the inked water with natural and synthetic dyes were measured before and after the filtration process, and color changes were observed.
- An initial test was conducted involving the germination of radish and spinach seeds. These vegetables were chosen due to their suitability as short-cycle crops for the environmental conditions of the community.
- Experiments were conducted with other suitable vegetables in the area to assess their growth and yield when irrigated with water tinted with natural and synthetic dyes that had been filtered.
- The laboratory analysis of water remained crucial, and it was managed at the appropriate instances to conduct a microbiological assessment and verify its purity.
- Based on the results, it will be possible to experiment with other types of vegetables.

Results

During the documentary research, the importance of homemade filters and their constituent materials was highlighted. Cotton emerged as a primary material, akin to gauze, responsible for retaining particles and sediments to enhance water quality. Acting as a mechanical barrier, it effectively traps impurities and suspended solids, resulting in cleaner water. Charcoal plays a crucial role in eliminating odors and tastes from chemicals or natural components. Gravel functions as a drainage bed, capturing larger particles and sediments. Meanwhile, sand is employed to retain solid particles in suspension, with an optimal diameter range of 0.5 to 1.5 mm.

Furthermore, the technique for collecting water destined for the filtration process was investigated. Subsequently, materials used in constructing the two filters were identified, encompassing the following activities:

- The bottom part of four containers was cut and washed correctly.

Figure 1.
Container cut

- We washed the heavy and light materials—sand, gravel, and charcoal—three times until they were thoroughly cleaned.

Figure 2.
Sand washing

Figure 3.
Gravel washing

Figure 4.
Coal washing

- Four pieces of mesh measuring 15 x 15 cm each were cut and used to cover the upper edges of the four containers.

Figure 5.
Mesh cut

Figure 6.
Placement of mesh on the upper Edge

- To set up the base for the filtered water, we utilized four 20-liter containers that had been cleaned beforehand. Additionally, we employed a wooden board with perforations where each jug was positioned upside down.

Figure 7.
Wooden board with perforations to place the filters

- Later, we began filling the containers. Initially, we filled two containers with sand and gravel, which are coarse materials. Subsequently, we filled the remaining two containers with cotton and charcoal, which are finer materials. Each pair of containers formed a complete filter, ensuring that the materials were evenly distributed.

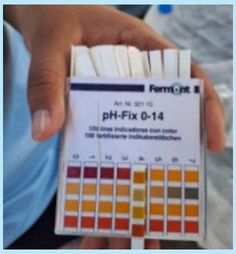
Figure 8.
Llenado de garrafón con arena y grava

Figure 9.
Llenado de garrafón con carbón y algodón

Members of the community engaged in dyeing wool textiles with natural and synthetic dyes were identified. Those who were informed about the project willingly provided us with inked water (synthetic, indigo, and cochineal). The collection was carried out using clean containers, and after collecting the inked water, each container underwent triple washing using the same inked water.

Subsequently, the water samples were transported to the educational facility. Before initiating the filtration process, pH levels and color of water were recorded. After filtration (filtered water), the same samples were re-evaluated. The resulting data were documented in Table 1 below:

Table 1. Average pH of Water Dyed with Natural and Synthetic Dyes, and Dominant Coloration

Type of Inked Water	Average pH of water		Mostly observed water coloration	
	Without filter	Filtered	Without filter	Filtered
Water Inked with Natural Indigo Dye	9 	8 	Intense Blue 	Sky Blue 
Inked Water with Natural Dy from Cochineal (Dactylopius coccus)	4 	7 	Deep Pink 	Soft pink 
Water Dyed with Synthetic Colorant	5 	8 	Strong blue-green 	Soft blue-green 

After recording the initial pH and color data, 5 liters of water mixed with 200 ml of inked water were placed into the first container filled with sand and gravel for filtration, focusing on water dyed with natural indigo. After 24 hours, the filtered water was transferred to the second container containing charcoal and cotton, completing the filtration process. Subsequent pH and color measurements were recorded and updated in the previous table, resulting in an average of 4 liters and 700 milliliters. This process was repeated in the second filter dedicated solely to filtering water dyed with synthetic dyes. It's important to note that the first filter has been consistently used for filtering water dyed with natural dyes, specifically indigo and cochineal, although efforts will continue to collect inked water from other natural dyes.

Figure 10.
Inked water with synthetic dye

Figure 11.
Inked water with natural dye

As observed in Table 1, the pH averages indicate that water dyed with both natural and synthetic dyes typically stabilizes around pH 8 due to the homemade filter's effectiveness. Although this pH level is basic, further experiments with different materials in the filter are planned to achieve a neutral pH. Notably, water dyed with cochineal grana dye showed a neutral final pH, which is considered suitable for irrigating vegetables.

Experimental trials involved germinating spinach and radish seeds in pots, each watered with the corresponding inked water: natural indigo dye, natural cochineal grana dye, and synthetic dye.

Figure 12.
Sowing radish and spinach sedes

Figure 13.
Watering with inked water

As of now, the seeds have germinated, and we are awaiting proper development.

Figure 14.
Spinach watered with filtered water dyed with natural dye (indigo) and synthetic dye

Figure 15.
Radish watered with filtered water of natural dye (indigo) and synthetic

Figure 16.
Radish watered with filtered water with natural coloring (cochineal grana) and synthetic

Further irrigation experiments will be conducted with other suitable vegetable species in the community to assess their growth and production. The outcomes of these experiments will guide the selection of additional materials for the homemade filter.

A laboratory practice was coordinated with the Technological Institute of Oaxaca to perform microbiological analysis on the filtered water. Due to administrative reasons, this analysis has not yet been conducted. Efforts are ongoing to establish the necessary connections to achieve the expected results.

Conclusions

Reusing inked water with natural and synthetic dyes presents and will continue to serve as a viable alternative in the community, enabling the establishment of additional production systems such as agricultural cultivation for food.

The project is particularly fitting for the community, given its reliance on wool rug production where water usage in dyeing processes is crucial.

Reusing filtered ink water in vegetable cultivation offers a pathway to enhance agricultural production systems that contribute to food security.

The project's feasibility in the community lies in the reuse of discarded water with natural and synthetic dyes, thereby supporting the implementation of other systems such as agricultural practices.

Contributions of the project

The project aims to intervene by addressing the issue of water scarcity for productive activities, particularly agricultural practices that support food production. This issue is widespread and manifests in various impacts related to water scarcity.

The project proposes an alternative approach where inked water containing natural and synthetic dyes used in wool textiles, a primary economic activity in the community of Teotitlán del Valle, will be reused. This activity accounts for the community's highest water consumption, yet the water is currently not reused in any manner.

This project not only addresses local challenges related to water scarcity and agricultural productivity but also aligns with broader global sustainability goals outlined in the SDGs. Through innovative approaches like reusing inked water and promoting sustainable practices, the project contributes towards achieving Zero Hunger (2), Clean Water and Sanitation (6), and Responsible Consumption and Production (12) goals on both local and global scales.

By reusing inked water from wool dyeing processes in vegetable cultivation, the project promotes sustainable agricultural practices. This helps increase food production locally, thereby contributing to food security and nutrition (SDG Target 2.1). Efficient water use through filtration and reuse also ensures more water availability for irrigation, which is crucial for enhancing crop yields and ensuring sustainable food production systems (SDG Target 2.4).

Furthermore, the project directly addresses water scarcity issues by repurposing inked water that would otherwise be discarded. This approach helps in conserving freshwater resources and reduces pollution of water bodies caused by untreated discharge from dyeing processes (SDG Target 6.3). Implementing homemade filters to clean and reuse water demonstrates a practical solution for communities facing water shortages, thereby promoting sustainable water management practices (SDG Target 6.4).

Lastly, reusing inked water aligns with SDG 12's objective of promoting sustainable consumption and production patterns. By integrating circular economy principles, the project reduces waste generation and encourages resource efficiency (SDG Target 12.2). It also emphasizes the importance of sustainable practices in textile production, where water-intensive processes can have significant environmental impacts. By demonstrating a method to reuse water and reduce environmental footprint, the project supports sustainable production practices (SDG Target 12.4).

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