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Natural Filtration: Exploring the Efficacy of Bamboo (Bambusa Vulgaris "Wamin") Fiber Strand with Carbonized Bamboo for the Reduction of Total Coliform in River Water

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Abstract: **The presence of total coliform bacteria in rivers represents a serious hazard to health and the environment, causing a highlight on the need for sustainable treatment options regarding water. This study examines bamboo (Bambusa vulgaris "Wamin") fiber strands in bamboo and their role in reducing total coliform from river water as a natural filtration media. Due to sustainable, fast-growing and naturally antibacterial features of bamboo, it makes a resourceful material for treatment solutions on water without harming the environment. In this study, the developed filtration media is a process combining bamboo fiber strands grinding and carbonization which is aimed at biofiltration maximization. These observations support the idea that, baring environmental concerns, treated bamboo material can be an effective and very cheap strategy for water purification purposes by carbonizing bamboo in a cost-effective manner to remove disease-causing organisms from water. Such chemical limitations underscore the need for additional research to focus on particular effective dosages and the shelf-life of the filtration material made of bamboo for practical faster performance.**

Keywords: **Bamboo Fiber, Carbonized Bamboo, Total Coliform, Natural Filtration, River Water.**

1. INTRODUCTION

Background of the Study

Water pollution is still one of the primary environmental and public health issues, particularly in areas that draw water from untreated or inadequately treated sources for drinking as well as agricultural or any other day-to-day use. An example of this, is the total coliform bacteria which is a large group of different microorganisms often found in the environment and used in epidemiology to indicate potential pathogenic contamination. The occurrence of coliforms within the water may also mean that other harmful systems like bacteria, viruses or even protozoa that are a threat to populations exposed to such unthreatened sources of water may also be present. (Suleiman & Ersoy, 2019).

While conventional approaches to water treatment may work, they often call for huge frameworks, sophisticated technologies and maintenance work which may not be available in rural or impoverished areas. This challenge has motivated limited-resource communities' water researchers to investigate cheap, eco-friendly and indigenous means for treating water (Saha et al., 2020). In these natural filtration methods, bamboo (Bambusa vulgaris "Wamin") has come as a potential material looking at its physical and chemical properties which aids in the effective filtration process.

Bamboo is a remarkable plant which features high tensile strength and is ecologically friendly and has various uses because of its high growth rate and natural antibacterial properties (Singh & Kumar, 2021). More particularly, bamboo fibers are porous and absorptive which means that they can absorb impurities like bacteria, suspended matter and organic materials. It has also been established that bamboo-filtration would be after that a thick layer has been applied that enhances the filtration of water from bacteria, hence this material is appropriate for use in domestic water filtration (Zhang et al., 2018). Another incorporated benefit that bamboo has is that it can be pre-treated by carbonization to further improve the adsorption levels of the material and improve it in the adsorption of bacteria such as total coliform (Ma & Peng, 2017).

The carbonization method by which bamboo is subjected to heat in a low-oxygen environment converts the material to activated carbon which has a bigger surface area with a greater ability to absorb organic compounds, heavy metal toxins and microorganisms (Lin & Wang, 2019). Use of raw bamboo fiber and carbonized bamboo combined in a filtration unit is very effective especially for filtration of total coliform bacteria and a host of other impurities. This dual filtration medium utilizes the adsorption of carbonized bamboo with bamboo fiber to enhance the efficiency of removal of contaminants (Rahman et al., 2021).

The effectiveness is being researched in this paper focusing on the use of Bambusa vulgaris “Wamin” fiber strands and carbonized bamboo to decrease the amount of total coliform in the river water. This research seeks to address a gap in the existing works as it examines the natural filtration ability of bamboo only, without the inclusion of any other filtration aids in view of its antibacterial activity. Most works available in the literature have examined the application of bamboo with other materials or as part of complex filtering constructions. This study will also demonstrate the value of bamboo and carbonized bamboo in terms of cost effective environmentally friendly filtering material as long as cut-off the bamboo fiber strands (Chen et al., 2020).

This research aims to fulfill the following objectives: (1) analyze the total coliform reduction in river water by employing a total organic carbon (TOC) bamboo water filter, (2) assess the performance of carbonized bamboo in bacterial filtration and (3) investigate the synergistic activity of bamboo fiber and carbonized bamboo in coliform reduction at varied configuration and combination ratio. This research highlights the technological aspect of bamboo filtration, which would be the contribution to the scientific knowledge on this topic, but more importantly provides a solution that is low cost and eco friendly to tackle the problem of water pollution, especially in marginalized regions (Ahmad & Yadav, 2022).

Finally, the recommendations made in this study would also enhance the discipline of environmental science as well as public health through the use of local and environmentally sound technologies for water purification. Bamboo, for instance, has been proven to be effective in this regard but has not been fully explored. That way it complements the aim of eliminating excessive chemical treatment for water and being one among the very few technologies that will help bring safe drinking water to the needy population in the regions where this technology will be applied (Martinez & Lee, 2021). In this context, we wish to dispel the concerns regarding the "there is no other way" attitude regarding the current systems and provide arguments for practical, efficient and low-cost systems, starting with bamboo.

2. METHODOLOGY

Research Design

A Descriptive Comparative Analysis will be employed to evaluate the impact of the offset time when Bamboo (Bambusa Wamin) is removed from a sodium hydroxide solution. The experimental units, wastewater samples, include pairs of filtered samples and a basic sample of untreated river wastewater from the Davao River. Each filtration system will be compared descriptively to each other and to the untreated wastewater to assess differences in total coliform reduction.

Figure 2

The descriptive comparative analysis provides insights into which filtration setup, with the time difference of submergence of the bamboo on the sodium hydroxide solution in water, results in a greater reduction of bacteria, specifically total coliform. Replications within each filter system ensure a more reliable assessment, while the inclusion of carbonized bamboo offers potential improvements in bacterial reduction compared to bamboo strands alone. This descriptive approach allows for a quantitative comparison of coliform counts, offering insights into the relative efficacy of each bamboo-based treatment system for wastewater within a controlled experimental framework.

Phase I

1.1. Collection of Bamboo(Bambusa Wamin)

To obtain the Bamboo (Bambusa Wamin), the researchers visited multiple shops and houses that contain bamboo in Davao City. Following the collection of the bamboo, the researchers then proceeded to cut the bamboo into four parts equally by 1ft of size each. Subsequently, the bamboo went through a thorough process of washing by flowing water to facilitate the production of the cleaned bamboo. Lastly, to facilitate the use of bamboo for carbon activation we separated half of the four 1ft sized bamboos. And have the remaining two be processed to fiber strands for the filtration system we designed, both will be processed in NaOH.

1.2. Collection of Wastewater Samples

Figure 2. Collecting Wastewater

The procurement of wastewater samples took place at Davao River located near Bolton Brg., Davao City. The methodology emphasizes the simultaneous collection of these samples as a unified set, ensuring synchronicity in the collection timeframe. This approach is essential to maintain consistency and minimize the potential for data manipulation or tampering. After the collection of wastewater, the unified set was tested to detect surfactants in the riverwater at the Davao Analytical Laboratory on Gen. Douglas MacArthur Hwy in Talomo, Davao City. Following this, the sample was divided into three for replication, totaling 3 wastewater samples. Following the careful collection and selection process, the three samples of wastewater were placed in jars for treatment. Given the limited scope for generalization of the number of samples, researchers emphasized the effects of Bamboo filter on the untreated river water.

Phase II

2.1 Soaking the Bamboo in Sodium Hydroxide

Figure 3. Soaking the Bamboo

The bamboo poles are immersed in a 4% sodium hydroxide solution for a period of 44 and 48 hours. This treatment aids in the extraction of lignin and hemicellulose from the cellulose structure of the bamboo fibers facilitating elevated pore volume and improved abilities in cluster molecules of these fibers to assist in eliminating bacterias.

2.2 Cutting the Bamboo

Figure 4. Bamboo Cuts

Cut the bamboo into half then cut into 4 more equal sides each piece of the bamboo. This is to manage the proper size and how to use it for the subsequent parts of the process.

2.3 Sun Drying the Bamboo

Figure 5. Bamboo drying

The bamboo was then cut to much thinner pieces and dried for 12h under the sun to evaporate most of the moisture in the bamboo.

2.4 Carbonization of the Bamboo

Figure 6. Bamboo Carbonization

Prior to carbonizing the bamboo, the bamboo undergo initial weighing to determine the amount of mass removed before and after the process. To facilitate the production of activated carbon from desiccated pineapple peels, the carbonization will be employed, involving thermal decomposition of the organic material. The location where the carbonization process was held in a researchers home in Davao City. This carbonization process is to be executed at a controlled temperature of 300 degrees Celsius, with a variable time span ranging from 120 minutes, aimed at optimizing the activation of the carbonaceous structure.

2.5 Processing the Bamboo Charcoal

Figure 7. Cancelling the Chemical

Processing the bamboo charcoal required the activated bamboo charcoal to be grinded into small pieces and was shifted to separate the larger pieces and to grind them again. This was repeated several times until the charcoal is as small and fine as dust. It was then mixed with citric acid, vinegar and heated at 200°C for 1h while being stirred to evaporate and instill the citric acid and vinegar on the charcoal. Doing this process is needed to properly eliminate the chance of the sodium hydroxide still remaining in the bamboo charcoal while also further activating the charcoal.

2.7 Neutralize the Sodium Hydroxide

Figure 7. Cancelling the Chemical

To neutralize the sodium hydroxide inside the bamboo, you would need to soak it in vinegar for 6 - 9h long, until it reaches a pH of (a neutral) 7. This is to ensure that there is only a little chance of the sodium hydroxide remaining in the bamboo and not inhibit possible unknown variable in the bamboo.

2.8 Peeling the Bamboo

Figure 8. Making the strands

The remaining Bamboo was used for making the strands for the filter. They were peeled around the size of 0.50 - 11mm wide and 3 - 4cm long strands and were put in a container with water to soak it and be tested for the pH level of the water.

Phase III

3.1 Size Separation of the Bamboo Strand

Figure 9. Small, Medium and Large.

Each Bamboo strands of the BW - 20 and BW - 22 were separated in three groups. Small, Medium and Large. This is to separate the needed sizes of the filter that requires different layers of bamboo strands.

3.2 Microbial Analysis of River Water for Total Coliform Reduction

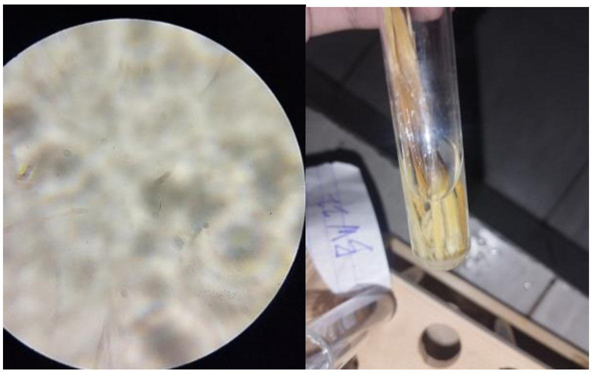

Figure 10. Looking under the Microscopes

This Phase starts with the microbiological evaluation in trying to ascertain how effective the bamboo filtration system can be in the removal of total coliform bacteria from the river water. Water samples will be taken and analyzed before and after passing through a fiber strand made of bamboo.

3.3 pH Testing of the Bamboo Filtration System

Figure 11. Checking the PH Level

In addition to the microbial analysis, this stage will also focus on the influence of the bamboo filter on water pH. As a starting point, river water pH will be determined prior to any water treatment. This will be followed by measuring the pH of treated water after it has passed through the bamboo filter in order to check for any changes that may be attributed to the bamboo material. A pH meter or pH strips will be used for these measurements to assess changes in the levels of acidity or alkalinity. Such changes would help interpret the chemical implications of using the bamboo filtration system on the quality of water.

3.4 Cutting the Bamboo Mold

Figure 12. Cutting the Bamboo Mold

The process of construction commences with the making of a bamboo mould, It was cut and had a height of 26 cm and width 7 cm. The tools used to do so was with a carpenting saw and it also was cleaned inside out with a brush. Which serves as the envelope for the system. Several pieces of bamboo are joined, cut, and molded to create the frame that will retain the filtration layers in place. This particular stage is essential for the proper working mechanism of the filter and its sturdiness.

3.5 Stuffing the Strands on the Bamboo Mold

Figure 13. Layering the Bamboo in the Mold

After the construction of the bamboo form, the next phase is filling it with the filtration elements in order to increase the purification efficiency. The first (the bottom) layer consists of a dense circular mesh which functions as a primary barrier and also includes a layer of activated charcoal – to prevent the escape of debris. A thinner cross hatch will be added in the second layer which will add the filtration process, plus an additional layer of activated charcoal to catch smaller debris. The final or top layer (top of the filtering bamboo), bamboo strips are woven in and bamboo dust is provided. This final layer is aimed to trap more smaller particles and is also effective in filtering through the ashes.

3.6 Adding the Bamboo Carbonated Charcoal and The Bamboo Ashes

Figure 14. Adding the Carbonized Charcoal

The last stage of constructing the filter is to put the bamboo carbonized charcoal and bamboo ashes which are crucial for increasing the filtration efficiency to the maximum. The total weight of each charcoal in the layers is 25 mg respectively and the ash with only 5 mg of it added, is only put in the top most layer of charcoal. The carbonized charcoal absorbs all the dirt and impurities while the ash of bamboo helps to cut the smaller impurities. These materials are then appropriately layered to finalize the filter which enhances the quality of water by efficiently reducing the contaminants.

Phase IV

4.1 Treatment Process

Figure 15. Adding the Carbonized Charcoal

The treatment process involves filtering river water through the bamboo filtration system created in the previous phases. Water samples are passed through the bamboo filter containing multiple layers such as mesh, carbonized charcoal, and bamboo ashes which are designed to reduce total coliform bacteria and improve overall water quality. This ensures that the total coliform is able to be reduced to the targeted percentage of what the research is for.

4.2 The Storage Of Treated and Untreated Water sample

Figure 16. Storage of the Water Samples

During this phase, the treated wastewater is transferred to a container, where it is kept for transportation. The container is designed to prevent contamination, evaporation, and odor emission of the treated wastewater. The treated wastewater is monitored for parameters such as adsorbent dose and contact time. The treated wastewater is adjusted if necessary to avoid spillage.

4.3 Delivery Method for Total Coliform Count

The River water samples collected from the treatment have a total of 3 samples, with each must have a volume of 250ml for the samples to be delivered effectively. The samples had to be put in the isolated container in 1-4°C while being on the six hour time frame of delivery to the DAVAO ANALYTICAL LABORATORY. For them to process the actual amount of the total coliform. This is to keep the microbial(total coliform) have a much better and accurate analysis of the total coliform count for each water sample.

The samples delivered to DAVAO ANALYTICAL LABORATORY had used the Standard Methods for the Examination of Water & Wastewater, 24 ed. This method ensures the accuracy and credibility of the river water samples treated with Carbonized Bamboo Filter by precisely separating, identifying, and quantifying individual components within the samples.

3. DATA ANALYSIS

Results obtained from studies conducted by Davao Analytical Laboratories, Inc. indicate the treatment efficiency in terms of residual total coliform detected in river water samples after various treatments involving bamboo (Bambusa vulgaris "Wamin") fiber strands and its carbonized form. The specimens under analysis comprised one control sample (BW^2-00) and two treatment samples (BW – 20 and BW – 22) that varied in the amount of bamboo filter media used. The total coliform levels recorded for each of the samples are illustrated below:

Table 1. Laboratory Results

Lab Ref No.	Sample ID	Parameter
		Total Coliform, MPN/100 ml
W_3-24-5257	BW - 20	54,000,000
W_3-24-5258	BW - 22	35,000,000
W_3-24-5259	BW^2 - 00	240,000,000

The control sample has recorded a very high coliform count (240,000,000 MPN/100 ml), that represents the baseline contamination of the untreated river water. The treatment in samples BW-20 and BW-22 showed lower total coliform, with BW-22 (35,000,000 MPN/100 ml) showing lower coliform level than BW-20 (54,000,000 MPN/100 ml). This indicates that the increase in the coliform count is inversely proportional to the amount of bamboo filter media used since higher concentrations of bamboo fiber and carbonized bamboo seem to be more effective in reducing the coliform levels.

4. RESULTS AND DISCUSSION

The study investigated the efficacy of utilizing Bamboo strands and activated bamboo carbon to reduce total coliform levels. It included a control group and two treatment trials: one submerged in NaOH for 44 hours and the other for 46 hours.

The table below presents the results of a descriptive comparative analysis on coliform concentration among three groups: BW-20, BW-22, and the control group (BW^2-00). The analysis shows substantial differences in coliform counts among these groups.

The coliform concentration was recorded as follows:

- BW-20: 54,000,000 MPN/100 ml
- BW-22: 35,000,000 MPN/100 ml
- BW^2-00 (Control): 240,000,000 MPN/100 ml

These values indicate that the treated groups, BW-20 and BW-22, have significantly lower coliform counts than the untreated control group. Specifically, BW-20 and BW-22 reduced coliform levels by approximately 77.5% and 85.4%, respectively, compared to the control. This suggests that the treatments are effective in reducing coliform levels, with BW-22 showing the highest reduction.

Table 2. Percentage of Reduction

Group	Coliform Concentration (MPN/100 ml)	Percentage Reduction Compared to Control
BW-20	54,000,000	77.50%
BW-22	35,000,000	85.40%
Control	240,000,000	-

These descriptive findings support the effectiveness of the treatments in lowering coliform levels in water compared to untreated samples, with BW-22 demonstrating the greatest reduction in coliform concentration.

The mean and standard deviation of coliform concentration in BW-20 and BW-22 show notable differences compared to the control group. Specifically:

- BW-20 has a mean coliform concentration of 54,000,000 MPN/100 ml.
- BW-22 has a mean concentration of 35,000,000 MPN/100 ml.
- The control group (BW^2-00) has a much higher mean concentration of 240,000,000 MPN/100 ml.

The control group exhibits the highest coliform concentration, while BW-22 shows the lowest. The lower concentrations in BW-20 and BW-22 indicate a substantial reduction in coliform levels compared to the untreated control, with BW-22 demonstrating the most significant decrease. This descriptive analysis reinforces the effectiveness of treatments in reducing coliform concentration in the water samples, especially in the BW-22 group.

5. CONCLUSION AND RECOMMENDATION

This investigation into the filtration capabilities of treated water samples has demonstrated a significant reduction in coliform concentration compared to untreated samples. The study aimed to evaluate different treatments for wastewater purification, specifically focusing on reducing coliform levels as a measure of water quality. Results indicate a substantial decrease in coliform levels in treated water samples BW-20 and BW-22 compared to the control sample BW^2-00. Among the treatments, BW-22 was the most effective, achieving the greatest reduction in coliform concentration.

These findings highlight the potential of specific water treatments in reducing harmful bacteria in wastewater, contributing to environmental safety and water quality improvement. It is recommended that future studies explore alternative concentrations and variations in treatment duration to further optimize coliform reduction. Additionally, exploring other treatment materials or combinations could provide further insights into efficient and sustainable water purification methods. This study has demonstrated the effectiveness of current treatments, with potential for optimization to enhance results further.

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