

Assessment of Water Purification Potential of a Biofilter Formulated with Luffa Sponge (*Luffa cylindrica*)

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Abstract

*The most important natural resource on earth is water. All forms of life (plants, animals, and microorganisms) cannot survive without water. If there was no water there would be no life on earth. This study assessed the efficacy of the Luffa Sponge (*Luffa cylindrica*) biofilter on its ability to decontaminate water with an emphasis on microbial contaminants for domestic purposes. This study shows that Coliform was reduced by 54%, Turbidity by 43%, TSS by 69.5%, pH was improved by 25.88%, Temperature by 7%, DO by 5.88%, and BOD by 15%, while change was not observed in EC with 0%. This result was compared with the Nigerian Water Quality Standard (NIS 554-2015) and found that *Luffa cylindrica* when compacted well, can be used to treat dam and pond water where there is no industrial waste discharge to fit for drinking in remote villages.*

Keywords: *Drinking Water, Biofilters, Luffa Sponge, Filtration.*

1. Introduction

The most important natural resource on earth is water. All forms of life (plants, animals, and microorganisms) cannot survive without water. If there was no water there would be no life on earth (George and Roger, 1991). Research shows that in Nigeria, like other African countries, especially in rural areas access to drinkable water is very difficult (Unicef, 2021). Village people travel miles to source water which is polluted in many cases. Because we require the greatest amount of water to carry out our everyday activities, the state of the available water that can adequately be used to achieve these feats becomes irrelevant, as the potable water supply is a major worry (USAID, 2021).

This work assessed the biofiltration efficiency of Luffa sponge Biofilter on Warwade dam water which is used for both Agricultural and domestic purposes. The dam is selected for its high percentage supply of the water used by many people residing in Warwade village, Dutse and surrounding communities. Many people from both Jigawa and Kano states use this water for Agricultural purposes and some of the village's populace for domestic uses.

However, this work was limited to one species of Luffa (*Luffa cylindrica*) because of its abundance in many communities and bushes of Northern Nigeria. This work was also limited to studying Luffa sponge performance concerning microbial decontamination, most especially coliforms. However, some of the physicochemical parameters were considered as well.

A Luffa sponge is a cellular biological substance. At low densities, these materials often have outstanding mechanical characteristics. While their mechanical performance lags behind that of synthetic materials such as metals, ceramics, polymers, and composites, they have long-term environmental sustainability as a structural material. (Jianhu et al., 2012).

Luffa sponge (*Luffa cylindrica*), a non-woody subtropical plant in the Cucurbitaceae family, is one of the cellulose sources (Khadir et al., 2021). The high cellulose content (55–90%), biodegradability, non-toxicity, cheap cost, lightweight, and eco-friendly qualities of luffa sponge fibers make it one of the most hopeful natural fibers (Anastopoulos and Pashalidis, 2020; Hong et al., 2020).

Due to its fast adsorption kinetics, broad surface area, and high stability features, luffa sponge fibers have been utilized as an effective adsorbent in the removal of heavy metals and dyes from contaminated water in the water treatment field (Anastopoulos and Pashalidis, 2020; Liatsou et al., 2017).

According to Ahmed et al. (2021), oxidized-fibers, cellulose, and oxidized nano cellulose extracted from sponge gourd fibers (*Luffa cylindrica*) employed as natural, non-toxic, and low-cost adsorbents absorbed more than 95 percent of lead and 85 percent of methylene blue from wastewater.

Awaluddin et al. (2020) used silver nanoparticles coated Luffa Sponge to disinfect wastewater and found that it has a strong disinfection potential. It has a greater total coliform Log Removal Value (LRV) of 3.3 and can disinfect at a high filtration rate while maintaining a consistent disinfection ability.

Although there have been a lot of studies done on this topic that tackles a lot of issues, purification of polluted or contaminated water to a drinking level using this media was yet to be verified. Most of the relevant literatures focus on wastewater treatment and agricultural water filtration.

2. Materials and Method

i. Sampling

Dried Luffa (*Luffa cylindrica*) was collected selectively from and around Warwade village randomly. About forty (40) liters of raw dam water sample was collected from the Warwade dam Dutse systematically. The sampling procedure used during the research work involves duplicate collection of water at each station. In this method, water was sampled at surface level by dipping 25 liters plastic jerry can sliding over the most upper surface of the water with their mouth against the water current to permit undisturbed passage of water into the jerry can. Two sub samples (50 cl each) were curved out from the mega samples. The first subsample was used to determine the physicochemical parameters while the second sub-sample was used for microbial analysis.

ii. Filter Construction

A filter model was constructed to investigate the efficiency of the luffa sponge in the filtering process. The model structure was made from roasted clay. The model consisted of four chambers each with dimensions of 15 cm x 15 cm height and radius respectively. The total height was 60 cm and the radius was 15 cm.

The filter medium (luffa sponge), was placed in three locations in the three separated chambers starting from the more porous to the lesser one in the direction of flow. The system was operated in series. Each compartment was separated by a locally made plate from a Date palm and the sponges were held in place to avoid the deformation of the filter media. The filter bed was provided with a side-bottom drain for collecting filtered water.

Porosity: The sponge pore sizes were measured in a dried condition. The values were obtained from the formula.

$$\text{Porosity} = \frac{\text{total volume of void}}{\text{total volume of sample}}$$

Low rate: Flow rate = In flow – Out flow per time

Retention time: Time is taken to complete one batch filtration process. This was determined using the formula

$$T^* = AD/Q$$

Where A = surface area (m²), Q = Flow through tank (m³/s), D = Depth of tank (m)

iii. Physicochemical Analyses for the Selected Parameters

From the raw water before filtration, the following parameters were determined. Turbidity was measured by adding a water samples into the turbidity tube until the black mark at the bottom center of the tube become diminished. The scale on the tube was read and recorded. pH was measured by inserting calibrated pH meter's electrode into the water sample. Reading was recorded from the digital display on the meter. Temperature (°C), Electrical Conductivity (EC), Dissolve Oxygen (DO), and Biological Oxygen Demand (BOD) were measured by using a Multimeter called YSI pro UK 2030. The multi-sensor electrode of the machine was inserted directly into the whole 40L raw water sample before being filtered; the digital result displayed was recorded. Total Suspended Solid (TSS) was determined by the use of membrane filters to assess the number of solid particles in water samples. Suspended solid (mg/l) = w₁-w₂

Where, w₂ = initial weight of evaporated dish (mg/l)

w₁ = final weight of evaporated dish and residue (mg/l)

iv. Bacteriological Analysis

Most Probable Number (MPN) method of bacteriological analysis was applied to determine the presence and quantity of indicator organisms (Cheesbrough, 2006).

Serial Dilution

Six sterilized test tubes were arranged serially. First test tube contains 10 ml of the raw water while the remaining 5 test tubes contained 9ml of distilled water. One (1) ml was transferred from the first test tube containing 10 ml raw water into second test tube containing 9 ml distilled water, then 1ml from the second test tube was also transferred to third test tube, third to fourth, fourth to fifth and fifth to sixth respectively. This process was to minimize the overpopulation of bacteria. This procedure was repeated 7 times to obtain at least 60 ml amount of the last dilution.

Media Preparation

Lactose broth media was prepared according to the manufactures guide 13 grams of Lactose Broth was Suspended in 1000 ml of distilled water. It was heated in order to dissolve completely. The media was dispensed in tubes containing inverted Durham's tubes. Sterilization was performed by autoclaving the media at 15 lbs. pressure (121°C) for 15 minutes (Greenberg *et al.*, 2020).

Inoculation

Ten (10) ml of the last dilution was transferred into each of the 5 test tubes each containing prepared lactose broth. One (1) ml of the last dilution was also transferred into each test tube of the second set of five test tubes. Lastly, 0.1mL was added to each of the last sets of five test tubes making fifteen (15) test tubes in total.

Incubation

The test tubes were incubated at 37^oC for 24 hours in an incubator. A change in cloudiness was observed

v. Biofiltration

Biofilters were placed upright, to achieve down flow of the water. Water was passed by down flow mechanisms through RF for screening and then passed through a fabricated biofilter slowly. The filtered water was collected in sterile 20 L plastic Jerry cans. Procedures **iii**, **v**, and **vi** were repeated with the filtered water, results were compared.

3. Results and Discussion

Table 1 depicts findings regarding the physicochemical parameters. Temperature (°C) shows a little decrease from 28^oC before filtration to 26^oC after filtration, this makes the water more comfortable for drinking and fishing activities, this change is due to filter casing made from roasted clay since clay has cooling properties. pH was reduced from 6.3 which is slightly neutral to weakly alkaline 8.5, it is within the Nigerian Standard for Drinking Water Quality (NIS 554- 2015), this is due to the luffa sponges properties as reported by (Adie *et al.*, 2013), because clay pots reduce water hardness. There was no change in Electrical Conductivity (EC), and the EC 130 µS/cm detected is within (NIS 554-2015). The DO for both before and after filtration (4.86 and 5.1 mg/L) is far less than the maximum permitted level (500mg/L). Turbidity has no direct health impact but can harbor microorganisms protecting them from disinfection and can entrap heavy metals and biocides. This can bring problems to the water treatment process and can also be a potential infection risk. The turbidity was 7 NTU which is above the 5NTU maximum permitted level, after filtration it improved to 4 NTU less than the maximum. Total Dissolve Solids was 105mg/L before filtration and 32mg/L; after filtration; this means 73mg/L was removed by the filter, although the maximum standard is 500mg/L.

Table 1: Shows the variation of physicochemical analysis before and after filtration

Parameter	Before Filtration	After filtration	Improvement
Temperature (°C)	28	26	2
pH	6.3	8.5	-2.2
Turbidity (NTU)	7	4	3
EC (µS/cm)	130	130	0
DO (mg/L)	4.86	5.1	0.3
BOD (mg/L)	0.95	1.12	0.17
TSS (mg/L)	105	32	73

Table 2 bacteriological analysis before filtration (coliform count) is presented. A positive sign indicates a positive test per test tube. Three replicate was used and their average was considered as the final number to be used, this helps to minimize random errors that may occur. Before filtration, a 5-5-4 pattern was obtained, and this pattern was interpreted from the Most Probable Number (MPN) Table as 1600 MPN Index/100 mL, which is equivalent to 17 cfu/mL. This result is above the (NIS 554-2015) standard. While looking at information in table 3 tells information about bacteriological analysis results after filtration in the same pattern as in table 2. It is found that the MPN pattern was 5-5-3 with 920 index/100mL that is MPN index was 9.2/mL; this means the filter removed 54% of bacterial load when compared to 17cfu/mL of the initial result. Moreover, it is slightly less than the maximum tolerable limit of the Nigerian standard for drinking water which is 10 cfu/mL according to the (NIS 554-2015) standard.

Table 2: Shows variation of bacteriological analysis before filtration (coliform count)

Replicate	Cloudiness change in Test tubes		
	1 st Division	2 nd Division	3 rd Division
1 st	+++++	+++++	++++-
2 nd	+ - +++	+++++	+++ - +
3 rd	+++++	++++ -	+ - +++ -
Average	+++++	+++++	++++ -

Table 3: Shows variation of bacteriological analysis after filtration

Replicate	Cloudiness change in Test tubes		
	1 st Division	2 nd Division	3 rd Division
1 st	+++++	+ - +++	++ - -
2 nd	+ - +++	+++++	+++ - -
3 rd	+++++	+++++	+ - +++ -
Average	+++++	+++++	+++ - -

4. Conclusion

This work shows that the constructed biofilter with three luffa sponge (*Luffa cylindrica*) layers of varying masses as filtration media can decontaminate microorganisms in the water to be fit for drinking. Efficiency assessment of the fabricated biofilter shows 54% decontamination. It is recommended to further this research by combining a luffa sponge and other natural filtration media such as silt sand, charcoal, roasted mood gravel, etc. to achieve maximum efficiency. Finally, this research will help in providing potable water to the countless rural communities populated by hundreds of thousands of people that currently don't have access to clean water; this will aid in minimizing the world water crisis. However, further research is necessary to make a pathway to find simpler methods for water purification.

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