

Research Article

Green Filtration of Total Solids from Various Water Sources Using Coconut Coir and Loofah

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Abstract: In this study, environmentally benign and readily available organic waste materials (coconut coir and loofah) were used as biofilters to remove total solids (TS) in water samples from various sources in Araromi Coastal Region of Ilaje Local Government, Nigeria. The TS levels observed in the river, pond, well, borehole, and seawater samples were 4,000, 1,610, 3,980, 2,600, and 34,800 mg/L, respectively. Generally, the organic filters reduced the TS in the water samples. Also, the sorption efficiency increased with the filter mass-to-water volume ratio. The overall performance of coconut coir was better than loofah, probably because the former has a more closely packed fibrous mesh. The optimum sorption efficiency of 60 g of the coconut coir filter for river, pond, well, borehole, and sea water was 50%, 78%, 80%, 92.3%, and 48.8%, while those for loofah were 42.5%, 56.3%, 70%, 84.6%, and 40.2%, respectively. This work showed that pretreated coconut coir is an efficient green filter for TS in water sources, especially boreholes, wells, and ponds.

Keywords: filtration, organic filters, *Cocos nucifera L*, *Luffa aegyptiaca*, total solids

1. Introduction

According to the World Health Organization (WHO), more than 33% of the human population have no access to safe drinking water [1]. WHO reported that approximately 1.6 million people, predominantly children, die every year from waterborne diseases [2]. Governments, corporate bodies, non-governmental organizations, and researchers are concerned that potable water scarcity remains a major global problem [3]. Moreover, global water demand could rise by 20 to 30% by 2050 [4], thereby requiring efficient water purification technologies. Therefore, it is crucial to identify an alternative to purify unpotable water using a low-cost, readily available, and low-tech method.

Boiling, liming, ozonolysis, chlorination, iodine or bromine treatment, UV-disinfection, ozonation, reverse osmosis, phytoremediation, bioremediation, adsorption, absorption, and filtration are among the techniques often used for water treatment [5]. Most of these techniques have shown inherent deficiencies, such as high energy demand, tediousness, high financial requirements, environmental hazard via secondary pollution and others. However, of these methods, filtration is the most conventional, convenient, and benign technique for separating solids from liquids [6,7].

Luffa aegyptiaca (luffa or loofah sponge) has been reportedly used to ameliorate ammonium-laden wastewater [8]. In this study, the efficiency ($79.4 \pm 8.82\%$) and durability of the green filter were found to be excellent. Earlier, loofah was used to control various surface water pollutants, such as alkalinity, chloride, ammonium, bacteria, and suspended

solids [9]. Therein, the authors reported 48.33% removal efficiency for total suspended solids (TSS). Meanwhile, coconut husk fiber (coconut coir), among other water purifiers (zeolite, charcoal, and membrane), has been tested for its rainwater purification efficiency [10]. The study found that the green filter is comparatively efficient, but it still requires some pretreatment and modification. In the same year, a group of scientists studied the use of loofah and coconut fiber to improve the biochemical oxygen demand, dissolved oxygen, turbidity, and color of the wastewater [11]. As a result, both organic filters managed to improve the water quality.

So far, no comparative study has been reported between pristine coconut coir and loofah filters on various water sources, especially seawater. Coconut trees flourish in high salinity regions, where potable water is often scarce. Therefore, in this study, locally sourced and readily available organic (green) filters derived from coconut coir and loofah were experimented on various water sources originating from Araromi Coastal Region, Ilaje Local Government Area of Ondo State, Nigeria.

2. Materials and methods

2.1 Sampling area and method

Araromi (longitude 4° 49' 59" E and latitude 6° 22' 43" N) is a rural coastal community in Ilaje Local Government Area, Ondo State, Nigeria. Samples were obtained from various water sources in Araromi, including the sea, estuary, river, well, pond, and borehole. The collected samples were stored in plastic bottles before use. Coconut coir was collected from a mature coconut tree (*Cocos nucifera L*) in Araromi, while the pristine and sundried loofah (*Luffa aegyptiaca*) used was obtained from a local market. 20, 40, and 60 g of each filter were precleaned in 1 M HNO₃ solution before copiously rinsed with distilled water. Finally, they were air-dried before being used.

2.2 Experimental setup

Initially, 50 mL of the water sample placed in a precleaned and dried 100 mL beaker was evaporated for 30 min in an electric oven set at 105 °C. Then, the beaker was transferred into a desiccator to cool to room temperature. Finally, it was reweighed. The total solids (TS) is calculated according to the following equation:

$$TS = \frac{(A - B) \times 1000}{\text{amount of water (mL)} \times 1000} \quad (1)$$

where A is the mass of the empty beaker and B is the mass of the beaker with dried solid. TS represents the sum of TSS and total dissolved solids (TDS) in water. TS is an indicator for characterizing water chemical properties, such as clarity, photosynthetic activities, and organisms' productivity. The initial TS concentration ratio of 2.5:1:2.5:1.6:21.6 in the river, pond, well, borehole, and sea water was recorded.

For the green filter, 20, 40, and 60 g of the organic filter were placed in a precleaned and dried funnel that was positioned on a 100 mL beaker. 50 mL aliquot was gently poured through the filter. The filtration process was assumed to be complete when no more drops were visible, which took approximately 1 to 4 min. The filtrate was then collected and analyzed for TS. The residual TS is determined by the difference in TS values with and without the organic filter.

Further, the removal or sorption efficiency, which is the percentage of TS uptake by the sorbent, also known as percentage removal, is determined by using Equation 2 [12],

$$\text{Removal efficiency} = \frac{C_0 - C_1}{C_0} \times 100\% \quad (2)$$

where C₀ and C₁ imply the TS concentrations before and after adsorption, respectively.

3. Results and discussion

Figure 1 depicts the TS residual concentrations observed when the biofilters were used on the seawater samples, while Figure 2 compares the biofilters' TS removal efficiency of the other water sources.

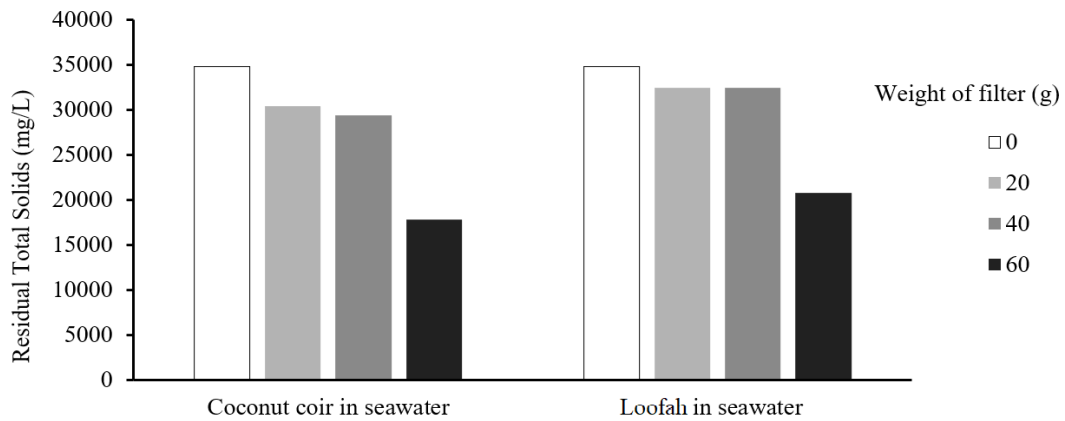


Figure 1. Residual concentration comparison of total solids in seawater for 20, 40, and 60 g of coconut coir and loofah filters

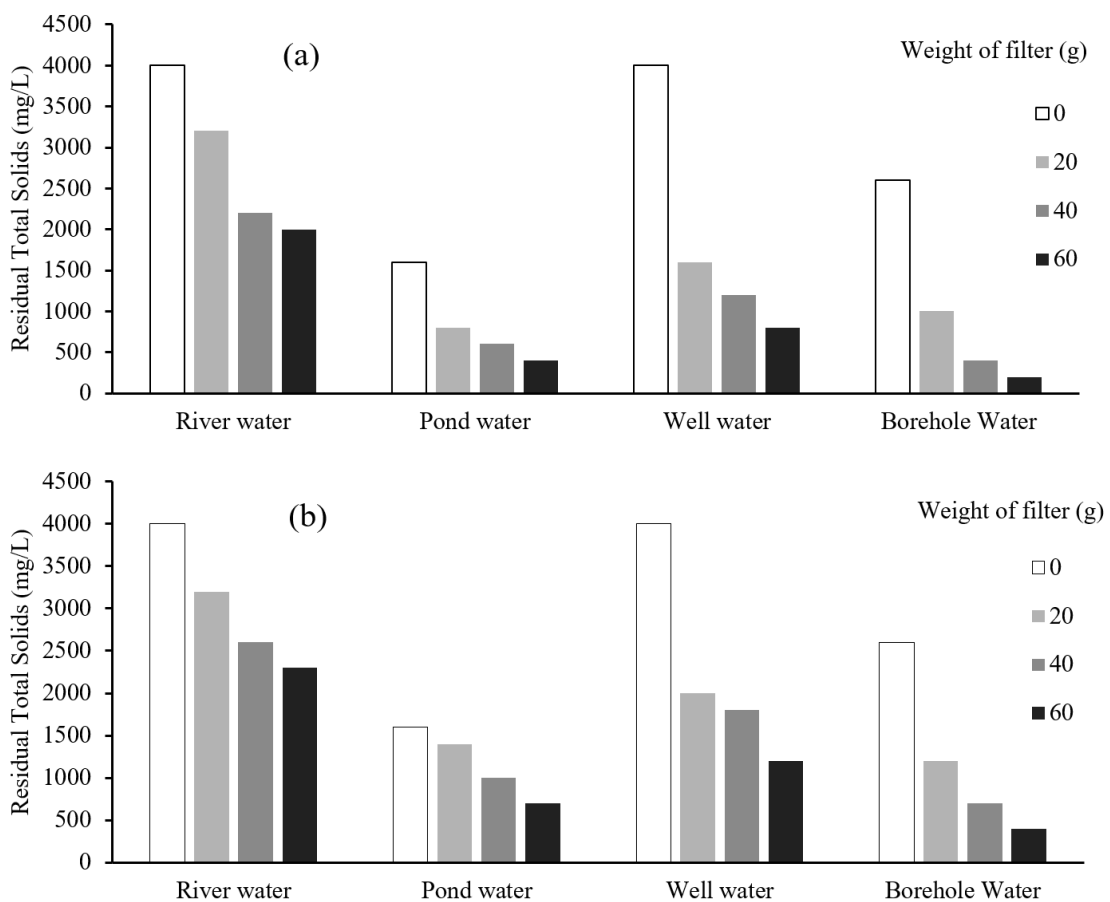


Figure 2. Residual concentration comparison of total solids in river, pond, well, and borehole water samples for different weights of (a) coconut coir and (b) loofah filters

The results showed that the TS concentrations in the water samples exceeded the WHO permissible limit of 500 mg/L [13,14]. Such high values could be attributed to the close proximity of water sources to the sea, which is frequently associated with high levels of suspended solids (SS) and TDS [15]. The results also showed that the TS concentrations decreased with increasing filter weight. Here, the TS levels for the pond and borehole water fell within the WHO permissible limit after the application of green filtration. Thus, it is proven that using the green filters on the pond and borehole water from the Araromi coastal region could result in water that is safe for human consumption.

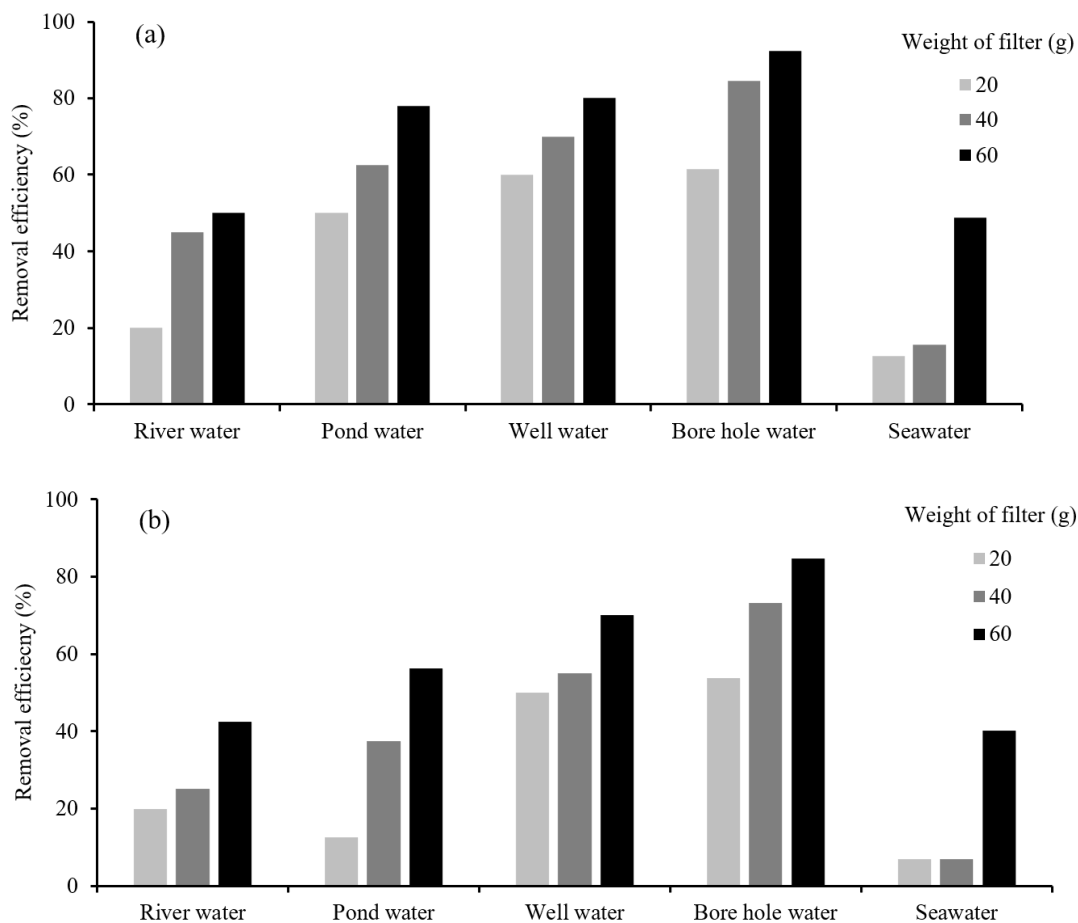


Figure 3. Removal efficiency comparison of total solids in river, pond, well, and borehole water samples for different weights of (a) coconut coir and (b) loofah filters

Figure 3 illustrates the results of the estimated removal efficiency. From this estimation, it is confirmed that coconut coir is more efficient than loofah. Also, despite their low concentrations of solids, the borehole water and seawater had the highest and lowest susceptibility to solid removal. As expected, the sorption efficiency improved with the filter weight, although not proportionally. For the pond and well water samples, the sorption efficiency was proportional to the weight of the coconut coir filter. However, in some cases, increasing the filter weight from 20 to 40 g was more effective when compared to the 40 to 60 g increment, particularly for the river and borehole water samples filtered using coconut coir, and pond and borehole water samples filtered using loofah. Meanwhile, it was the reverse for the sea water samples filtered with coconut coir, and the river and seawater samples filtered using loofah. These haphazardness or anomaly could be attributed to the accidental release of fines from the filters due to the absence of binders that could adhere the filter fibers together, or the lack of calcination of the green filters during sample preparation.

The optimum performance reported in the present work was compared with previous studies where different techniques and materials were used to remove solids from various water samples (Table 1).

Table 1. Optimum removal efficiency comparison achieved under different total solids removal methods

No.	Material used	Method used	Optimum removal efficiency	Ref.
1	Nonwoven geotextile	Upward filtration system	88.5%	[16]
2	Fe electrodes	Electrocoagulation	99%	[17]
3	Pumice and Sand-gravel mixture	Media filter systems	90.5%	[18]
4	Okra powder	Coagulation-flocculation	73%	[19]
5	Chemical additives $Al_2(SO_4)_3$	Electroflocculation	98%	[20]
6	Waste bivalve shells	Simple filtration	81%	[21]
7	Natural Esker	Sand filtration	40%	[22]
8	Coconut coir	Simple filtration with virgin material	48.8 – 92% (depending on the water source)	Current study

By comparison, only electrocoagulation [17] and electroflocculation [20] techniques performed better than the current study's filtration method using coconut coir. Meanwhile, the sand filtration method requires an upgrade to provide better performance even though the optimum removal efficiency is the lowest (see Table 1) [22]. For this reason, the excellent performance of the coconut coir filter has proven to be a viable option for a simpler water purification method.

4. Conclusion

The present study identified that both coconut coir and loofah biofilters were able to remove TS from the river, pond, well, borehole, and seawater samples. Although the biofilters' sorption efficiency increased with the weight of both coconut coir and loofah filters, the coconut coir showed better and consistent performance across the water samples. From the initial TS concentration ratio of 2.5:1:2.5:1.6:21.6 in the river, pond, well, borehole, and sea water, the coconut coir filter was able to achieve the optimum sorption efficiency of 50%, 78%, 80%, 92.3%, and 42.8%, while those for loofah were 42.5%, 56.3%, 70%, 84.6%, and 40.2%, respectively. As a result, coconut coir is an effective TS biofilter, particularly for water samples from boreholes, wells, and ponds.

In the future, more research involving the feasibility of enhancing the filters' performance via surface charging should be done. It is also recommended to explore the chemical characterization of the surface chemistry and pore-size distribution for the possibility of chemisorption and physisorption studies of the material used.

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