

ORIGINAL RESEARCH PAPER

Proposing a sequentially configured glass sand and coconut shell biochar media for drinking water treatment

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ABSTRACT

Human activities generate various by-products and residues, which can be valorised in several fields, particularly in water treatment. The aim of this study was to assess the performance of glass sand combined with coconut shell biochar in the filtration process of drinking water. To achieve this objective, the raw materials were collected and processed into filter media, then characterised using physical (crushing, sieving, etc.), chemical (laboratory analysis), and standardised methods. A pilot filter was constructed, and filtration tests were carried out to evaluate the effectiveness of the filter media in water treatment. The main results of the study revealed that the glass sand had particle sizes ranging from 0.02 mm to 12 mm; and that the biochar was obtained in two granulometric fractions (500 µm–12 mm), with specific surface areas of 227.81 m²/g and 178.17 m²/g respectively. Following filtration tests, the pilot filter demonstrated substantial removal of physico-chemical pollutants (turbidity: 91.8%, nitrate: 80.69%, copper: 77.42%, nitrite: 84%). These performances suggest that the pilot filter may be suitable for further experimentation at the household or industrial scale

Keywords: Activated carbon; Adsorption; Filter media; Pyrolysis; Water treatment

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Introduction

Access to safe drinking water is essential for human health and well-being. However, many regions of the world still suffer from limited access to potable water, leading to public health issues and the spread of waterborne diseases. Water filtration is an effective method for removing impurities, making the water suitable for drinking. It ensures access to high-quality drinking water, thereby improving population health and preventing the transmission of water-related illnesses (Kingue et al., 2023). It is estimated that the 4 billion cases of diarrhoea reported annually, resulting in 1.87 million deaths among children under the age of five, are caused by unsafe water, poor sanitation, and inadequate hygiene (Nguedia et al., 2023; Lantagne & Clasen, 2012). Sub-Saharan African countries are the most affected, as the majority of the population

relies on water sources with unacceptable levels of treatment and hygiene (Nguedia et al., 2022; Agassounon et al., 2012 ; Nguedia et al., 2024).

In France, in 2021, around 2.2 million tonnes of household glass packaging (bottles, jars, and pots) were recycled to manufacture new containers. As these are made from sand, they can serve as substitutes for sand in various applications (Kua et al., 2024). The use of glass waste as raw material is a major asset in improving the living environment in Benin (Milohin, 2019). In this context, in Côte d'Ivoire, it was highlighted that disorder within cramped homes creates a favourable environment for the survival of Anopheles mosquitoes, thus increasing the risk of malaria among household members (Brissy et al., 2017). In Cameroon, single-use hollow glass containers are poorly valorised; they are discarded

into the environment after a single use, contributing to pollution. It is therefore crucial to address the issue of excess glass waste in the environment. A key advantage of glass recycling is the reduction of waste volume, conservation of natural resources, energy savings, and the limitation of CO₂ emissions (PAPREC, 2025).

Activated carbon is an amorphous structure generally produced after a high-temperature carbonisation process. It has a very high specific surface area, which gives it excellent adsorptive capacity (Mamane et al., 2018). Adsorption is considered the most favourable technique for pollutant removal (Ahmed & Dhedan, 2012). This treatment method involves trapping pollutants using a solid material known as an adsorbent. Various adsorbents (such as clays, zeolites, activated alumina, agricultural residues, industrial by-products, and activated carbon) can be used in water treatment processes (Benamraoui, 2014). Therefore, the use of filtration systems emerges as an appropriate technology for improving the quality of drinking water in Cameroon, given the numerous advantages it offers.

The objective of this study is to evaluate the performance of glass sand and coconut shell biochar as filtering media in the process of drinking water filtration. Specifically, the study aims to produce activated biochar and glass sand derived respectively from the slow pyrolysis of coconut shells and recycled glass bottles. The resulting glass sand and biochar were used to construct a pilot granular filter with variable mesh size. The performance of this filter was then assessed through filtration tests and laboratory analyses.

MATERIAL AND METHODS

Production and Characterisation of the Filtering Media

Production and Characterisation of the “Glass Sand” Medium

For the production of glass sand medium, we used soda-lime glass from “Heineken” bottles, typically employed for beer storage. After collecting these glass bottles from waste disposal sites, they were washed and rinsed to eliminate odours and all types of impurities. The bottles were then manually crushed to obtain particles of various grain sizes. As the crushing progressed, the glass particles were separated using sieves of different mesh sizes, selected appropriately for the study, and stored in a clean shelter. Finally, the crushed glass was washed using basins, pasteurised, and dried on a clean surface. The characterisation of the different grain sizes of the filtering medium was carried out

following standard granulometric methods (sieving, weighing, and immersion techniques).

Production and Characterisation of the Coconut Shell Biochar Medium

➤ Collection of Raw Material

Coconut shells were selected as the raw material, as charcoal can be produced from plant, animal, and mineral precursors such as wood, bark, wood pulp, coconut shells, olive pits, peat, and petroleum residues, according to Ibanez (2002).

➤ Biochar Production

The collected coconut shells were cleaned and subjected to slow pyrolysis at high temperature (between 400 and 900°C). This process is a thermochemical treatment of raw material carried out in the strict absence of oxygen or any other oxidising agent (Kaltschmitt et al., 2009). After cleaning and drying the shells at 105°C for 2 hours, they were pyrolysed under temperature conditions essential for standard pyrolysis. The temperature during the process was monitored using a thermocouple/thermometer.

➤ Biochar Activation

To increase the specific surface area of the biochar, chemical activation using phosphoric acid was performed. This procedure involved first grinding the biochar obtained after carbonisation, followed by rinsing and drying in an oven at 105°C for 2 hours. A 50% phosphoric acid solution was then used to activate the biochar over a 24-hour period. After activation, the biochar was rinsed several times with distilled water until a stable pH of 8 was achieved, and then dried in an oven to allow evaluation of the activation rate.

➤ Chemical and Physical Analysis of the Biochar

The determination of the physical parameters of the biochar was carried out by soaking 100 g samples of each particle size fraction for 72 hours. After this soaking period, several measurements were taken on the biochar in both water-saturated and non-saturated conditions. Parameters such as adsorption capacity, specific surface area, density, bulk density, and porosity were thus determined. The chemical parameters related to the mineralising properties of the biochar were assessed after calcination in a crucible at 700°C until ash formation. The ash was then dissolved in distilled water, and analysis of the resulting solution allowed quantification of elements including calcium, magnesium, iron, potassium, zinc, phosphate, and sodium. The pH, electrical conductivity, and total dissolved solids were determined after soaking a

10 g biochar sample—previously ground to a particle size smaller than 163 µm—for 72 hours.

These parameters were measured using a multiparameter instrument. The ash content was determined according to the standard ASTM method. Briefly, 0.1 g of pre-dried sample was placed in a dry crucible of known mass and heated in a furnace at 650°C for 3 hours. After cooling to room temperature, the crucible was weighed, and the resulting mass corresponded to the ash content.

Pilot Filter settings and test

For the setup of the pilot filter, parameters such as grain size distribution, filter height, and thickness of the filter bed were taken into account. Accordingly, various materials and equipment available on the local market were utilised. A 20 L plastic bucket was used to represent the water storage tank to be filtered; plumbing materials, equipment, and tools were also employed. Figure 1 presents the two-dimensional layout of the pilot system implemented.

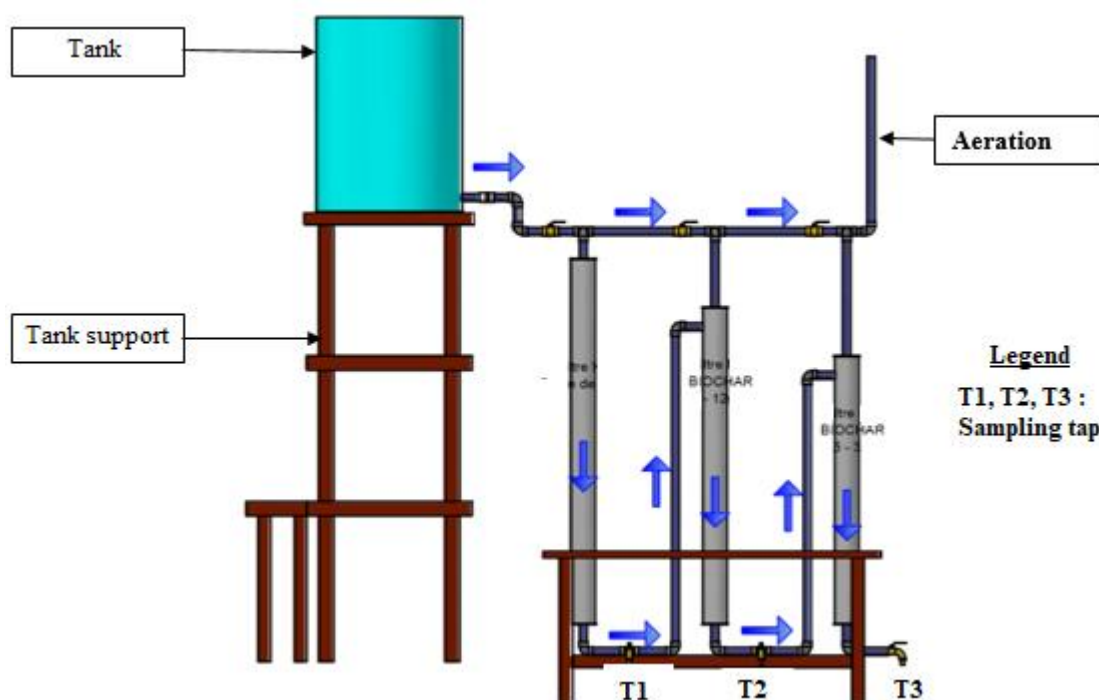


Figure 1 : 2D plan of the pilot system to be implemented

Evaluation of the Performance of the Pilot Granular Filter

The sample was collected from a dam at an ambient temperature of 20°C, following recommended site sampling procedures. Part of the sample was stored in a cooler to prevent any changes before analysis. In-situ parameters were measured directly on-site during sampling using a multiparameter device. Nitric acid solution was used to preserve the samples and avoid any alterations between sampling and analysis; a cooler was used to maintain the samples under appropriate climatic conditions.

After collecting the raw water sample for filtration, analyses were first conducted on the source sample to confirm the presence of the target pollutants for this study. Once verified, the reservoir was filled, and filtration tests and subsequent sample collections began. All collected samples underwent physicochemical analyses, which were performed using colorimetric assays and readings with a PC-Multidirect spectrophotometer,

employing a reagent-in-capsule technique. The device was calibrated using a distilled water sample, and after mixing the test sample with the reagent for 5 minutes, it was placed into the device's well for measurement. Nitrite LR, Nitrate LR, and Copper No. 1 reagents were used to quantify nitrite, nitrate, and copper, respectively.

In addition to the laboratory methods used for characterising the filtering media, the following standard formulas were applied to determine parameters related to the granular filtering media.

- Uniformity coefficient

$$C_u = \frac{d_{60}}{d_{10}}$$

With

d_{60} : effective diameter of the sieve that allows 60% of the filtering material to pass through and

d_{10} : effective diameter of the sieve that allows 10% of the filtering material to pass through.

- Bulk Density of the Material ρ (g/ml)

$$\rho = m/V_m$$

With:

m: Mass of the material (g) and

V_m: Volume of the material

➤ Density (**d**)

$$d = \frac{\rho_v}{\rho_e}$$

Where:

ρ_v = Bulk density of the material and

ρ_e = Density of water

➤ Porosity (**P**)

$$P = \frac{V_v}{V_t}$$

With:

V_v: Volume of voids between particles (m³)

and

V_t: Total volume of the material (m³)

➤ Permeability (**K in m/s**)

$$k = \frac{\mu \cdot e \cdot V}{\Delta P} \quad (\text{Darcy, 1856})$$

With:

μ: Dynamic viscosity of water (Pa.s)

ΔP: Pressure drop (m),

V: Filtration velocity (m/s) and

e: Thickness of the filtering medium (m)

➤ Permeability Coefficient

$$K = \frac{\Delta P}{e}$$

➤ Biochar Activation Percentage

$$\text{Burn-off} = \frac{m_i - m_f}{m_i} \times 100$$

With:

m_i: Mass of the biochar before activation

and

m_f: Mass of the biochar after activation

If the **Burn-off** is less than 50%, micropores are predominantly formed; and if it ranges between 50% and 75%, mesopores are produced (Ndongo, 2021).

➤ Ash Content (**T_c**)

$$T_c = \frac{m_i - m_f}{m_i} \times 100$$

m_i: Mass of the biochar before furnace treatment and

m_f: Mass of the biochar after furnace treatment

RESULTS AND DISCUSSION

Glass Sand and Coconut Shell Biochar

The various physical and chemical methods used for the production of the filtering media enabled us to obtain the detailed results presented below.

Glass Sand Characteristics

After the collection, cleaning, and crushing of the selected bottles, four (04) sieves with different mesh sizes were used to separate the particles and determine the effective grain sizes (**D10**) and (**D60**), which allowed us to calculate the uniformity coefficient (**CU**). The characteristics of the glass sand are summarized in Table 1.

Table 1: Characteristics of the Produced Glass Sand

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Grain Diameter (D) (mm)	0.02-0.5	0.5-0.9	0.9-3	3-8	8-12
D10 (mm)	0.6	0.8	1	3	5
D60 (mm)	0,7	1	1,4	5	10
Coefficient of Uniformity (CU)	1.17	1.25	1.40	1.67	2
Density (d)	1.78	1.83	1.86	1.97	2.10
Porosity (P)	0.79	0.71	0.54	0.48	0.43

These results demonstrate that, using recycled glass, we obtained media with several desired grain sizes for water filtration; these diameters ranged from 0.02 mm to 12 mm. Figure 2 presents the different grain size distributions obtained after crushing the glass.



Figure 2: Glass Sand Obtained in Different Grain Sizes

The results in Table 1 show that, using recycled glass, we obtained media with various desired grain sizes for water filtration; these diameters ranged from 0.02 mm to 12 mm. Similarly, the data indicate that the sieve size

allowing 60% of the material to pass through varies between 0.7 mm and 10 mm, while the sieve size allowing 10% of the material to pass ranges between 0.6 mm and 5 mm. The ratio between these sizes allowed us to obtain a uniformity

coefficient ranging from 1.17 to 2. These values show that grades 1, 2, 3, and 4 have a homogeneous grain size distribution ($CU < 2$), whereas grade 5 has a more widely graded grain size distribution ($CU > 2$). These results further show that, for the same chosen water volume and filter conditions, the bulk density increases from 1.78 to 2.1 from grade 1 to grade 5. This can be explained by the fact that the smaller the grain size, the lower the weight. Recycled glass media with finer grains tend to have higher porosity due to their greater specific surface

area. In other words, the number of pores decreases as the grain size increases.

Characteristics of Coconut Shell Biochar

From the collection to the carbonisation of the coconut shells, 30 kg of coconut shells were obtained. After cleaning and drying, the mass was estimated at 27 kg.

a) Carbonisation Parameters

To produce biochar of satisfactory quality, several parameters were taken into account. Table 2 summarises these carbonisation parameters.

Table 2: Carbonization Parameters

Mass Before Carbonization (kg)	Mass After Carbonization (kg)	Average Pyrolysis Temperature (°C)	Pyrolysis Duration (Hours)	Biochar Yield (%)
27	10	730	4	62.96

The use of a traditional kiln necessitated temperature monitoring inside the furnace. To this end, the temperature was measured during the first two hours using a thermocouple. These measurements allowed observation of the temperature evolution throughout the process. Figure 3 shows a visual representation of the obtained biochar.



Figure 3: Biochar Obtained After Carbonization

The temperature curve evolution shows that during our study, the temperature varied between 277°C and 830°C. It is notable that at the beginning of the pyrolysis, the temperature remained below the typical pyrolysis temperature, which is likely due to the use of a wood fire, resulting in a lower initial temperature. Despite this variation and the lack of temperature stabilisation, the temperature remained within the range indicated for pyrolysis. Consequently, the remainder of the experiment was conducted at an average temperature of 715.30°C. This value corroborates the findings of Bounaas (2015) and Ndongo (2021), who respectively indicate temperature ranges of 400–1000°C and 400–800°C for effective biochar pyrolysis. This temperature is higher than that used by Drissa et al. (2009), who applied 400°C; this difference can be explained by their use of a pyrolyser capable of maintaining a stable temperature. During this study, a carbonisation yield of 37.03% was obtained, indicating good

carbonisation of the coconut shells. This yield corresponds to a mass loss of 17 kg compared to the initial mass of 27 kg. This result is moderately close to that found by Kouadio et al. (2019), who reported a yield of 30.74%. The difference between the two values can be attributed to the nature of the raw materials—coconut shells in our case and cocoa shells in theirs—as well as the size of the raw materials subjected to carbonisation and activation. Indeed, our material ranged in size from 10 mm to 25 mm, compared to sizes below 10 mm used by Kouadio et al. (2019). Temperature likely also influences mass loss and can explain the difference in yield between the two studies. This aligns with the findings of Tchakala et al. (2012), who showed that increasing the temperature during the process correlates with higher charcoal yield. Moreover, Tchakala et al. (2012) demonstrated that increasing the particle size of shea and cotton biomass used for charcoal production leads to higher pyrolysis yields. This moderate influence of particle size is explained

by the fact that internal diffusion resistance is lower in small particles compared to larger ones. Consequently, as particle size increases, the mass yield increases because H_3PO_4 cannot easily diffuse into the pores of larger particles.

b) Activation
Activation for 24 hours using phosphoric acid produced several results, which are presented in Table 3.

Table 3: Biochar Activation Parameters

Mass Before Carbonization (kg)	Mass After Carbonization (kg)	Mass Subjected to Activation (kg)	Mass After Activation (kg)	Activation Rate (%)
27	10	9	6.5	27.78

The activation degree obtained in this study was 27.78%. This value is below 50%; this observation suggests that the activated carbon derived from coconut shells tends towards microporosity and mesoporosity. This also confirms the findings of Ndongo (2021) in the study on the synthesis and characterisation of ferromagnetic activated carbons from cassava peels, where it was stated that if the burn-off is below 50%, micropore formation occurs. This aligns with the results of Drissa et al. (2009), who confirmed a microporous and mesoporous structure in activated carbon after calcining coconut shells. An explanation for these findings is that the compact nature of coconut shells makes it unlikely for a macroporous structure to develop, regardless of activation conditions. This activation rate is lower than the 70% reported by Fernandez Ibanez (2002), who physically activated

the calcined material; this difference suggests that physical activation is preferable to ensure good carbon porosity.

c) Chemical and Physical Analysis of the Charcoal

Laboratory analyses enabled the determination of the essential parameters of our biochar. The analysis shows that it is primarily composed of calcium, magnesium, and sodium. The high calcium concentration observed was also reported by Zaiter (2017) following chemical analysis of activated carbon derived from date palm stems. This characteristic of our produced biochar could explain its capacity to mineralise water after filtration. The evaluation of the physical parameters of the biochar in the laboratory yielded the results presented in Table 4.

Table 4: Physical Parameters of Biochar

Biochar Sample	Bulk Density (g/cm ³)	Adsorption Capacity (kg/m ² .h)	Porosity	Specific Surface Area (m ² /g)	Ash Content (%)
Grain Size (500µm-3mm)	0.67	0.36	0.33	227.81	4.6
Grain Size (4mm-12mm)	0.65	0.19	0.35	178.17	4.6

The specific surface area obtained in our study for coconut shell biochar was 227.81 m²/g for the 500 µm–3 mm grain size fraction and 178.17 m²/g for the 4 mm–12 mm fraction. These values are lower than those reported by Drissa et al. (2009), who measured approximately 1310.13 m²/g for activated carbon derived from the same raw material carbonised at 900°C. Our values are also lower than those found by Hazourli et al. (2007), who reported values of 750, 950, and 1100 m²/g, and those found by Balogoun et al. (2015) after chemical activation with phosphoric acid of date stone and coconut shell charcoals, respectively. This discrepancy is likely due to differences in the carbon activation methods. Indeed, Drissa et al. (2009) used a physical activation method employing carbon dioxide and nitrogen as oxidising agents, whereas our method involved chemical activation using

phosphoric acid. However, our obtained values are closer to those of Kouadio et al. (2019), who reported a specific surface area of 610 m²/g for cocoa shell biochar carbonised at 610°C under similar chemical activation conditions to ours. The variation in specific surface area among these studies can probably be explained by several factors, notably the nature of the raw material, temperature, and type of activation. Based on the results in Table 4, we note that the relatively low ash content of about 4.6% could be advantageous for synthesising biochar with a high specific surface area. Given the low ash content, the biomass is composed almost entirely of organic matter, particularly carbon, with a content of 95.04%. This observed value is comparable to charcoals prepared from other lignocellulosic materials such as kola nut shells (Ndi et al., 2014), corn cobs (Abo et al., 2020)

at 6%, and cassava peels at 4.9% (Ndongo, 2021). Our value is also close to that obtained by Gnonsoro et al. (2015) on the same raw material.

Physical characteristics of pilot Filter and Filtration performances

The pilot filter set up consists of a 20-litre storage tank, a variable grain size glass sand filter, a coarse-grained activated biochar filter, and a fine-grained activated biochar filter. The physical characteristics of the pilot filter are detailed in Table 5.

Table 5: Characteristics of the Pilot Filter

	Glass sand	Biochar 1	Biochar 2
Total Bed Thickness e (m)	1	1	1
Filtration Rate V (m/s)	0.0286	0.0588	0.0400
Filtration Area S (m ²)	0.0079	0.0079	0.0079
Filtration Flow Rate Q (l/s)	0.224	0.462	0.314
Head Loss ΔP (m)	1.3	1.2	1.1
Permeability k (m/s)	1.98E-05	4.41E-05	3.27E-05
Permeability Coefficient K	0.022	0.05	0.036
Hydraulic Gradient i	1.3	1.2	1.1

In addition to the hydraulic parameters, the pilot filter is equipped with several components (control valves, reservoir, aerator) to ensure its operation. Table 5 presents the multi-stage pilot system, consisting of a 20-litre storage tank, a variable grain size glass sand filter, a coarse-grained activated biochar filter, and a fine-grained activated biochar filter. The direction of water flow is downward. This setup is similar to that described by Disa-Disa et al. (2014) in that the pilot is multi-stage and consists of filters arranged in series. The differences between the two pilots lie in the type of materials used, the direction of water flow, and the number of filters. Specifically, our pilot comprises three filters with downward flow, using glass sand

and biochar as filter media, whereas Disa-Disa et al. (2014) present a pilot with four filters arranged in upward flow, using only quartz sand as the filtering medium. These differences in configuration and composition are likely due to the treatment objectives, particularly the pollutants targeted for removal. The pilot filter also differs from that implemented by Gwenz (2018) in terms of the number of filters, their arrangement, and the nature of the filtering materials.

After sampling the water and conducting several filtration tests, analyses of some physico-chemical parameters revealed results for filters arranged both in parallel and in series. These results are summarized in Table 6.

Table 6: Filtration Test Results Based on Chemical Parameter

Parameters	Initial sample	Filter 1 (glass sand)	Filter 1 and 2	Filter 1. 2 and 3	Filter 2 (Biochar 1)	Filter 2 and 3	Filter 3
PH	7.5	6.79	7.29	8.39	7.19	7.82	7.69
Temperature (°C)	21.7	21.5	21.6	21.8	22	21.7	21.8
Electrical Conductivity (PPm)	56	59	162	2710	295	589	574
Turbidity (NTU)	122	9	15	10	25	23	28
TDS (PPm)	28	29	81	1370	147	300	287
Nitrate (mg/l)	10.2	3.9	3.8	1.97	2.2	2	2.1
Total Iron (mg/l)	0.21	0.11	0.1	0.1	0.06	0.1	0.14
Total Nitrogen (mg/l)	19.2	9.6	10.3	7.8	6.5	6.4	6
Copper (mg/l)	0.93	0.39	0.36	0.21	0.13	0.09	0.1
Nitrite (mg/l)	0.05	0.02	0.02	0.01	0.01	0.009	0.01

The filtration tests revealed an upward or downward variation of chemical parameters after passing through the different filter media. The temperature remained relatively stable throughout the study, oscillating between 21.5°C and 22°C. The pH showed a considerable increase when the liquid passed through the three filters, reaching a value of 8.39 compared to 7.5 for the initial sample. The

dissolved salt content and electrical conductivity increased across all filters, with a more marked rise observed in the case of the three filters arranged in series. Conversely, the other parameters underwent a significant reduction after passing through the various filters, whether arranged in parallel or in series. Figures 4 to 6 illustrate these variations in chemical parameters during the filtration tests.

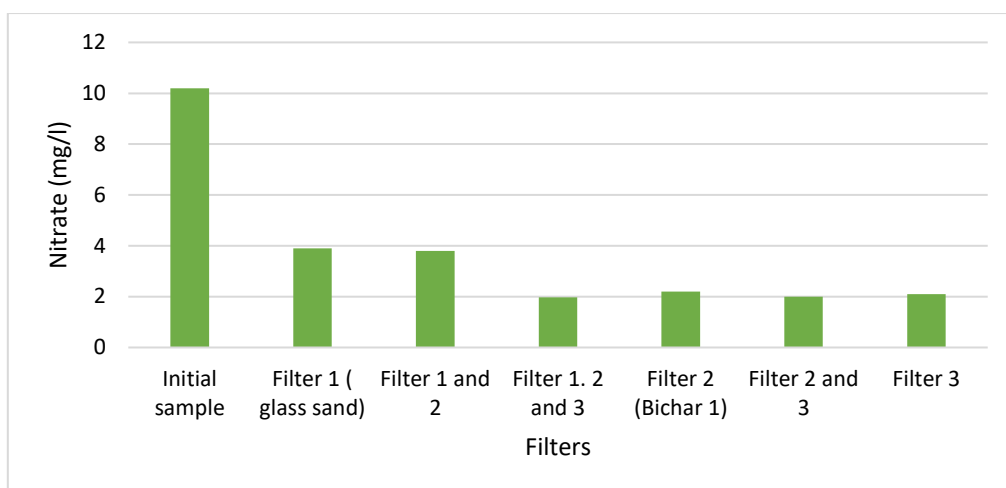


Figure 4: Nitrate Variation in the Filter

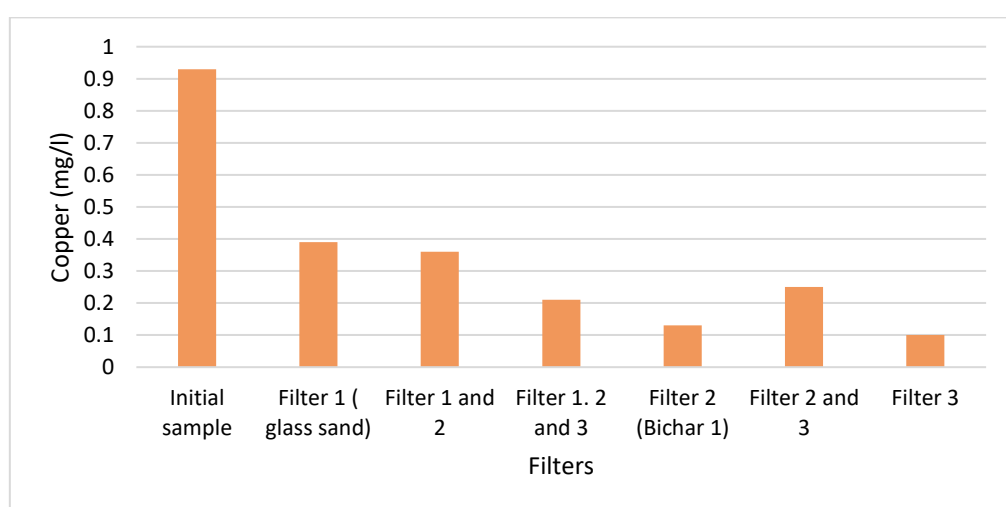


Figure 5: Copper Variation in the Filter

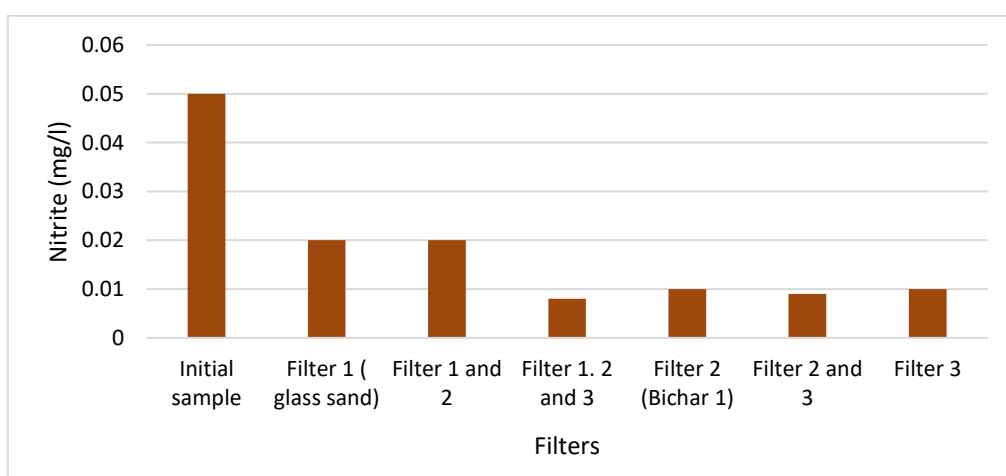


Figure 6: Nitrite variation in the filter

The filtration tests showed minimal variation in the glass sand filter for parameters such as pH, conductivity, and total dissolved solids (TDS). This can be explained by the fact that glass sand influences these parameters primarily through its porosity, rather than any significant chemical

reaction. However, these parameters increased in the biochar filters and across the three filters arranged in series. This could be due to insufficient rinsing of the biochar during the chemical activation process. Furthermore, the biochar, being rich in minerals, may have released elements chemically,

causing a gradual increase in pH and conductivity. These results corroborate the findings of Bezgrari (2024), who studied the effects of biochar on certain chemical parameters. Turbidity decreased significantly (77.05% to 92% removal) during the tests, whether the filters were tested individually or in series. This result highlights the capacity of these filter media to effectively contribute to the physical treatment of water through their inter- and intra-granular porosity, removing suspended particles. These findings are consistent with those reported by Zaiter (2017). The glass sand demonstrated physical treatment performance comparable to that of conventional sand, supporting the conclusions of Kua et al. (2024).

Figures 4, 5, and 6 show the variation of several chemical parameters (copper, total iron, nitrate, nitrite, total nitrogen) during the treatment tests. It can be observed that the glass sand filter had a minimal effect on removing these parameters. The reduction observed in this filter is unlikely due to a chemical reaction with the medium but may result from the indirect removal of chemical elements through the elimination of suspended particles. In contrast, these parameters showed significant reductions in tests involving the coconut shell biochar media. This can be attributed to the biochar's high specific surface area, enabling it to adsorb the chemical elements analysed in this study. These results align with those of Maleki Shahraki and Mao (2022) and Gwenz (2018), who used biochar to remove pollutants from drinking water. Copper removal by the biochar mirrors findings by Youcef et al. (2019), who reported effective copper removal using activated carbon. The nitrate removal observed in our pilot filter after adsorption concurs with results from Kheliel et al. (2015, 2017). Similarly, iron levels decreased due to adsorption on our charcoal, consistent with findings of Manel, and Thayer (2015, 2017). Overall, the pilot filter demonstrated remarkable performance in turbidity removal, a result comparable to that found by Lengaye et al. (2019), who reported a 50% turbidity removal rate after filtration. Mamane et al. (2018) similarly achieved effective chromium removal from water using adsorption tests with *Balanites aegyptiaca* (L.) Del. and coconut shell charcoal. Greater diuron removal was noted by Gbamele et al. (2016) following adsorption tests with coconut shell charcoal. The study by Randrianantoandro and Ramanantsoa (2023) showed a 98.04% removal efficiency of Indigo Carmine dye after adsorption onto coconut shells.

All these findings further substantiate the efficiency of biochar in eliminating chemical pollutants from water.

CONCLUSIONS

The objective of this study was to evaluate the performance of glass sand and coconut shell biochar, used in series and parallel configurations, in the potable water filtration process. Recycling glass enabled the production of glass sand with a variable granulometry and characteristics similar to conventional sand. This first medium was used to construct the initial compartment of the pilot filter. The coconut shell biochar obtained and chemically activated with phosphoric acid exhibited a high specific surface area and was characterised by a microporous structure. Chemical analysis revealed a high content of calcium, sodium, and potassium in the biochar. Two granulometries of this medium were used to build the other two compartments of the pilot filter. Filtration tests performed with the assembled pilot filter demonstrated effective removal of targeted pollutants (nitrate, nitrite, copper, and others) present in the initial water sample. From this study, it can be concluded that the use of recycled materials such as glass sand and biochar represents an effective, eco-friendly, and economical alternative for water filtration. The results indicate that these materials are particularly efficient at removing turbidity, nitrates, nitrites, copper, and other chemical pollutants. Further research could include filtration tests on other water types (rainwater, borehole water, well water) using the same setup; conducting filtration experiments with a programmable solenoid valve to control water residence time in the biochar filter; and testing the system within existing water facilities.

Conflict of interest

This research was carried out through collaborative efforts and shared insights of all the authors, who combined their expertise to enhance the quality and depth of the study. With a shared commitment to the accuracy of the findings, all authors reviewed and approved the final manuscript, ensuring it met high scholarly standards.

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Authors Contributions

Conceptualization: R.N.J

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Investigation: R.N.J, A.K.D

Methodology: A.K.D

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Validation: K.D.N

Visualization: K.D.N

Writing—original draft: B.N

Writing—review & editing: B.N

Availability of Data and Materials

All necessary data are incorporated and supplementary data can be accessed through the corresponding author.

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