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ECOFILTER: SMART EVALUATION AND MONITORING OF WATER USING GREEN TECHNOLOGY

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ABSTRACT

The pollution of the Barra Nova River in Caicó-RN has significantly impacted the local community and a nearby school, degrading water quality and increasing mosquito proliferation. The research question was how the protocols from the GLOBE Program and GLOBE Observer can contribute to evaluating and monitoring the factors that affect water quality, promoting environmental awareness within the community by utilizing green technologies. This project aimed to develop a sustainable filtration system using green technology to monitor and improve water quality, supported by the GLOBE protocols. The methodology involved creating an ecofilter from PET bottles, charcoal, coconut shells, cotton, and gauze. Water samples were collected and analyzed before and after filtration using the Water Quality Index (WQI), incorporating physical-chemical tests (pH, alkalinity, conductivity, temperature, transparency) based on the GLOBE Hydrosphere Protocol, and microbiological analyses using nutrient agar and TCBS for Vibrio cholerae. The results showed a significant improvement in water quality, with physicochemical parameters resembling those of distilled water, and a reduction in pathogenic bacterial growth. The ecofilter demonstrated its potential for enhancing sustainability and public health. The GLOBE protocols, particularly the Hydrosphere and Globe Observer protocols, played a crucial role in guiding water quality assessments and raising community awareness of environmental issues. Future recommendations include expanding the use of these protocols for continuous monitoring, increasing local engagement in environmental education, and exploring broader applications of green technologies to further improve water quality and sustainability in the region.

Keywords: Ecofilter, Hydrosphere Protocol, Microbiological Control, Water Quality.

1. RESEARCH QUESTIONS

This research was guided by several key questions aimed at understanding how the application of the GLOBE Program and GLOBE Observer protocols can contribute to assessing and monitoring water quality in the Rio Barra Nova, focusing on physicochemical and microbiological parameters. Understanding the effectiveness of these protocols is crucial for both local and global environmental monitoring efforts, providing significant insights into the impact of water pollution and the role of sustainable technologies.

A central question was to evaluate the performance of the ecofilter developed using sustainable materials like charcoal, coconut shells, cotton, and gauze. Specifically, the research aimed to investigate the ecofilter's ability to remove visible contaminants and microbiological pathogens from the polluted river water, which has severely impacted local public health.

The study also sought to explore how green technologies, such as the ecofilter, can reduce pollutants and improve water quality in urban areas affected by pollution. This investigation is vital for understanding the broader applications of eco-friendly solutions in addressing global water scarcity and pollution.

Another key focus was examining the impact of the project on the local school community. How did the development and implementation of the ecofilter engage students and residents in environmental awareness? The research aimed to evaluate whether participation in educational initiatives like workshops and the creation of educational materials helped increase understanding of water preservation and sustainability.

Lastly, the research aimed to assess the effectiveness of the ecofilter in removing both visible impurities and pathogens, and how environmental education initiatives could foster long-term changes in attitudes toward water conservation and sustainable practices.

2. INTRODUCTION AND REVIEW OF LITERATURE

Water pollution is a growing problem that severely impacts water quality, public health, and biodiversity. The degradation of water bodies, such as rivers and lakes, poses significant risks to aquatic life and human activities, leading to outbreaks of waterborne diseases and affecting food security and the economy. Pollution arises from industrial, agricultural, and domestic waste, introducing chemicals, heavy metals, excess nutrients, and pathogenic microorganisms into water bodies. Fecal coliforms and other pathogenic bacteria represent a serious threat to public health (Silva et al., 2020). These pathogens are responsible for infectious diseases that directly affect vulnerable populations.

In addressing pollution, environmental education plays a key role in raising awareness of environmental issues and promoting the conservation of natural resources. Educational programs - such as workshops, lectures, and school activities - are effective in mobilizing the community and encouraging responsible water conservation practices (Lima, Dos Santos, & Vasconcelos, 2024). Environmental education not only fosters sustainable habits but also empowers citizens to actively participate in the development of public policies aimed at protecting local water bodies.

Additionally, the use of green technologies has emerged as an effective solution for treating contaminated water. Materials such as activated carbon, coconut shells, and biological filters efficiently purify water, providing low-cost and sustainable solutions. Activated carbon, known for its high adsorption capacity, is effective in removing organic contaminants and heavy metals, while coconut shells are effective in filtering suspended solids and impurities (Mendes et al., 2020; Ribeiro, 2021). These technologies are ideal for developing affordable water treatment solutions in areas affected by pollution.

The GLOBE Program (Global Learning and Observations to Benefit the Environment) offers valuable protocols for environmental monitoring. The GLOBE Hydrosphere Protocol, which measures parameters such as pH, alkalinity, conductivity, temperature, turbidity, and transparency, is essential for effective water resource management (GLOBE, 2020). These protocols also encourage community participation by engaging local populations in data collection and raising awareness of environmental issues.

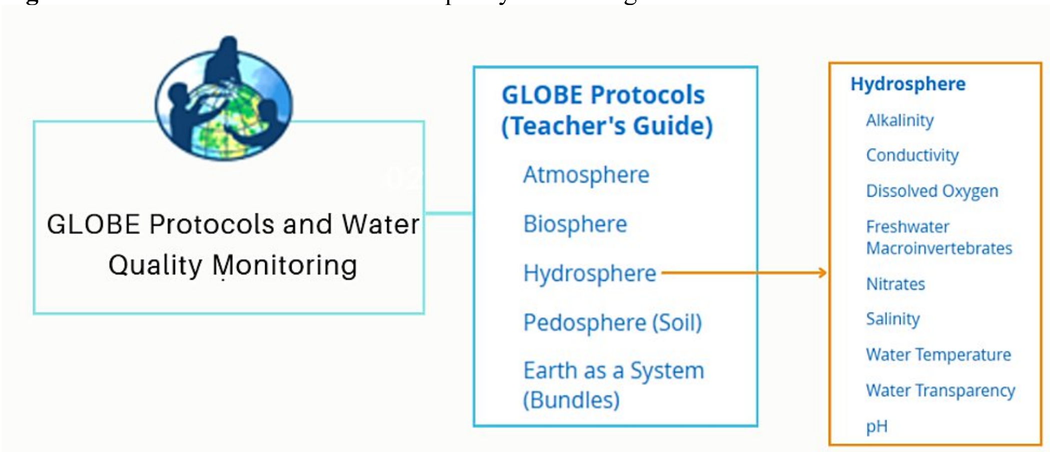
Microbiological water control is crucial for ensuring water safety. The use of nutrient agar and TCBS (Thiosulfate-Citrate-Bile-Sucrose) Agar enables the detection of pathogens such as Vibrio cholerae, the causative agent of cholera, ensuring that water meets the required safety standards for human consumption (Costa & Senna Junior, 2022).

This project is of great importance as it addresses critical issues of water pollution, public health, and environmental conservation. The development of sustainable solutions such as the ecofilter, made from locally sourced and affordable materials, provides an effective alternative for purifying water in regions affected by pollution. The application of the GLOBE Program and GLOBE Observer protocols will allow for continuous water quality monitoring, as well as promote environmental awareness and community involvement in the preservation of water resources.

3. RESEACH METHOS

The experimental methodology of this study was designed to create, test, and evaluate the effectiveness of a sustainable water purification filter, utilizing eco-friendly and accessible materials. The research was conducted following the protocols of the GLOBE Program, particularly the Hydrosphere Protocol, as shown in Figure 1, which involves the monitoring of physicochemical parameters, alongside microbiological control of water from the Barra Nova River, a source heavily impacted by pollution. The methods and materials used are outlined below.

Figure 1 – GLOBE Protocols and water quality monitoring



Source: GLOBE Protocols

3.1 Materials Used

The materials used included a 1.5-liter PET water bottle, a metal sieve, gauze, cotton, activated carbon, coconut shell, and the KP AA0008- Knup conductivity meter (Knup). The pH was measured using pH test strips (Merck), and the temperature was recorded with a thermometer. Water samples were collected from a stream near the Barra Nova River. For microbiological analysis, Nutrient Agar and TCBS Agar (Himedia) were used. The pH was measured using pH strips.

3.2 Water Sample Collection and Analytical Procedure

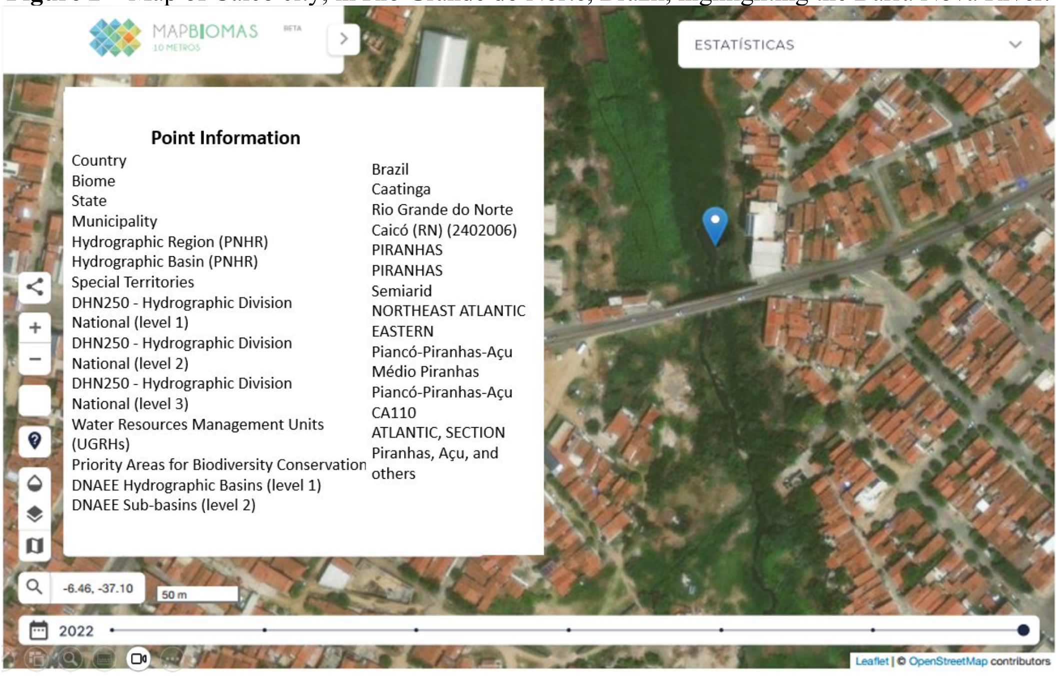
A 500 mL water sample was collected from the Barra Nova River, an easily accessible point in the western zone of Caicó-RN, where the water is visibly polluted due to urban waste disposal and improper use by the local population. This river is used by the community for animal consumption and laundry. After collection, the sample was divided into two portions: one was analyzed before filtration, and the other after filtration, in order to compare the effects of the filtration process on water quality. Some tests were conducted on-site (in situ) immediately after the sample collection, ensuring data accuracy. The samples were analyzed promptly to ensure the integrity and precision of the obtained information.

To properly store and test the samples, the following steps were taken, according to the GLOBE protocol:

- A 500 mL polyethylene bottle was labeled with the site name, the date and time of collection.
- The bottle and cap were rinsed with the sample water three times to eliminate any contaminants.
- The bottle was filled with the sample water until the water formed a dome shape at the top, ensuring no air was trapped inside when the cap was sealed.
- The cap was put on and sealed with masking tape. Note: The tape served as both a label and an indicator to show if the bottle had been opened. The tape did not come in contact with the water sample itself.
- The samples were stored in a refrigerator at about 4˚C until they could be tested (within 2 hours for pH, and within 24 hours for alkalinity, salinity, or electrical conductivity).
- Once the seal was broken, the tests were performed in the following order: salinity or electrical conductivity, pH, and finally alkalinity. The sample was allowed to reach 20˚-27˚C before testing for electrical conductivity. Ideally, all measurements were performed during the same lab session.

Figure 2 shows the satellite image of the Barra Nova River, in Caicó city, Rio Grande do Norte, Brazil.

Figure 2 – Map of Caicó city, in Rio Grande do Norte, Brazil, highlighting the Barra Nova River.



Source: https://plataforma.brasil.mapbiomas.org/agua/caico

In an attempt to develop an ecofilter to improve the quality of water used from the Barra Nova River, the Water Quality Index (WQI) was applied in a modification of the original Scottish Water Quality Index (House, 1989), adapted by Cymes and Glińska-Lewczuk (2016) for low-gradient watercourses in northeastern Poland. The WQI, as one of the most widely used water quality procedures, allows for the determination of a potential economic use of water, which in itself is an important tool to be employed in water management (dos Santos Simoes et al., 2008).

The parameter index is based on the aggregation of three groups of parameters, and the following analyses were performed: physical (filtration, temperature, conductivity, turbidity), chemical (pH and alkalinity), and organic (microbiological control of water). All data were standardized to a mean of 0 and a standard deviation of 1, eliminating scale biases.

3.3 Filtration Procedures and Physicochemical Testing

The Ecofilter prototype was designed using a 1.5-liter PET water bottle, a metal sieve, gauze, cotton, activated carbon, and coconut shell, arranged in a specific order. Activated carbon was chosen for its adsorption properties, particularly for removing impurities and heavy metals. Coconut shell was selected for its ability to filter suspended solids, while cotton and gauze were used to assist in retaining larger particles.

After the water collection, the samples underwent filtration through the filter developed in the project. The filtration process is the combination of environmental education and practical, sustainable actions is the key to transforming attitudes toward water use and conservation. Through active participation in developing and implementing the ecofilter, students and community members not only provided a solution for water purification but are also empowered to become stewards of their local environment.

This project represents a model for sustainable and collaborative action that could be replicated in other communities, contributing to improved water quality and responsible environmental practices at local and global levels.

After collecting the water samples, they were filtered through the prototype developed in this project. The filtration process involved slowly pouring the water through the PET bottle, which contained the layers of filtering materials (activated carbon, coconut shell, cotton, and gauze). The filter was positioned vertically to maximize the volume of water purified, as shown in Figure 3.

Figure 3 – Representation of the filter prototype used for the filtration of the samples.

Source: Author's own figure

3.3.1 Transparency and Temperature

Before filtration, the transparency and temperature tests were conducted on-site (in situ) immediately after the sample collection, following the GLOBE protocols to ensure data accuracy.

A sample of surface water was used with the transparency tube, given that it is from a shallow water source. The temperature of the water was measured with an immersion thermometer, as per the GLOBE protocol. The thermometer was immersed in the water sample, collected and transferred to beakers, and allowed to stabilize. The temperature was recorded in degrees Celsius (°C). To ensure accuracy, the measurements were performed in triplicate at different times of the day, observing any seasonal or circumstantial variations.

After filtration, the physicochemical tests for temperature and turbidity of the water were redone, including measurements of pH, alkalinity and conductivity. To ensure the integrity and precision of the obtained information, the samples were analyzed promptly, within 10 minutes of collection and this assessment was conducted on at least three different samples to ensure consistency in the results.

3.3.2 Alkalinity

Alkalinity was determined by titration, due to the absence of a test kit for this parameter. Alkalinity refers to the water's capacity to neutralize acids, and it is often associated with pH. It is primarily influenced by the presence of bicarbonate ions (HCO_3^-), carbonate ions (CO_3^{2-}), and other compounds that can buffer the water against drastic pH changes. The alkalinity of the water was determined using the acid-base titration method (Figure 4), in line with GLOBE guidelines.

Figure 4 - Acid-Base Titration of Water with Phenolphthalein

Source: Author's own design

The water sample was placed in an Erlenmeyer flask, and the volume was measured. After this, a hydrochloric acid (HCl) solution was added until the color of an indicator, usually phenolphthalein, changed, signaling the end point of the titration. The amount of acid required to neutralize the carbonate and bicarbonate ions was recorded, allowing the calculation of alkalinity in milligrams of calcium carbonate (mg/L). The measurement was performed in duplicate to ensure accuracy.

3.3.3 pH

To conduct the pH analysis of the river water, the top section of the Hydrosphere Investigation Data Sheet was first filled out with the necessary information. Next, the box in the pH section of the form was checked, indicating that pH paper was used for the measurement. Latex gloves were put on to ensure safety and avoid direct contact with the water sample.

Then, the beaker was rinsed with the sample water three times to ensure there were no residues or contaminants from previous samples. The beaker was filled halfway with the river water sample, and the instructions that came with the pH paper were followed. A piece of pH paper was dipped into the water, and the resulting color was compared with the provided color chart.

The pH reading was recorded on the form as Observer 1. Steps 4 to 6 were repeated with new water samples and fresh pieces of pH paper, and the results were recorded on the form as Observers 2 and 3. Then, the average of the three measurements was calculated.

It was checked to ensure that all measurements were within 1.0 pH unit of the average. Since the measurements were within this range, no further testing was needed. Finally, the used pH papers and gloves were disposed of in an appropriate waste container, and the beaker was rinsed with distilled water to ensure no residues remained.

The recorded pH values were then compared to the recommended pH ranges for natural waters according to the GLOBE parameters.

3.3.4 Conductivity

The electrical conductivity of the water was measured using a Knup kp-Aa008 conductivity meter, as per the GLOBE protocol. The water sample was placed in beakers, and the meter was immersed in the sample. First, two 25 mL beakers were rinsed twice with sample water. About 10 mL of the water to be tested was then poured into both beakers. The cap was removed from the probe end of the meter, and the on/off button was pressed to turn it on.

The probe was rinsed with distilled water and blotted dry, making sure not to rub or stroke the electrode while drying. The probe was then placed in the water sample in the first beaker, stirring gently for a few seconds, ensuring that the meter did not rest on the bottom of the beaker or touch the sides. Afterward, the probe was taken out of the first beaker, gently shaken to remove excess water, and then placed in the second beaker without rinsing it with distilled water.

The probe was left submerged in the second beaker for at least one minute. Once the readings stopped changing, the value was recorded on the Hydrosphere Investigation Data Sheet as Observer 1. Two other students then repeated the measurement using fresh beakers of water each time. The meter did not need to be calibrated for each student, and their measurements were recorded as Observers 2 and 3.

The average of the three observations was calculated for distilled water, unfiltered water, and filtered water, and it was verified whether each of the measurements was within 40 µS/cm of the average. If one or more values were not within 40 µS/cm, a new sample was poured, and the measurements were repeated, calculating a new average. If all measurements were still not within 40.0 µS/cm of the average, possible water quality issues would be present.

Finally, the probe was rinsed with distilled water, blotted dry, and the cap was replaced on the meter. The beakers and sample bottle were rinsed and dried. Conductivity was recorded in microsiemens per centimeter (µS/cm), with the measurement being performed in duplicate to ensure data consistency. Conductivity indicates the water's ability to conduct electricity, which is related to the presence of dissolved salts and minerals. Measurements were conducted at a controlled temperature, as temperature can influence conductivity values.

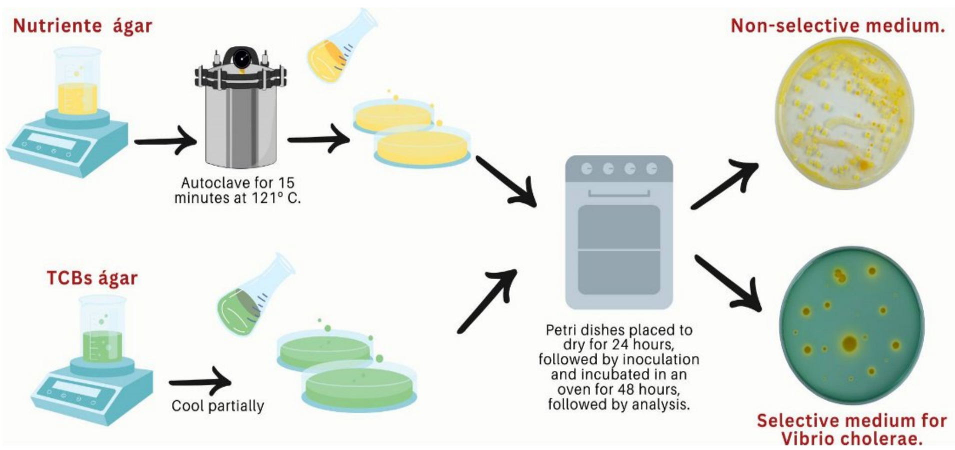
3.4 Microbiological Tests

For microbiological analysis, conducted to identify microorganisms present in the water, two types of culture media were used, in addition to the Globe protocol: Nutrient Agar and TCBS Agar. Nutrient Agar, a general-purpose medium composed of peptones, beef extract, and agar, was used to cultivate a wide range of microorganisms present in the water. This non-specific medium supports the growth of various bacterial species and fungi. In contrast, TCBS Agar (Thiosulfate-Citrate-Bile Salts-Sucrose Agar) was specifically employed to detect *Vibrio cholerae*, the causative agent of cholera, and other *Vibrio* species. This selective and differential medium contains thiosulfate, citrate, bile salts, and sucrose, which inhibit the growth of non-*Vibrio* species while promoting the growth of *Vibrio* species. *Vibrio cholerae* typically forms yellow colonies on TCBS Agar due to its ability to ferment sucrose, making it easily distinguishable from other microorganisms.

The collected water samples were separated for microbiological testing. For Nutrient Agar preparation, 28 g of agar powder was dissolved in 1 liter of distilled water. The solution was heated while stirring until the components dissolved completely. It was then transferred to an Erlenmeyer flask, wrapped in brown paper, and autoclaved for 15 minutes at 121ºC. After autoclaving, the medium was poured into sterile Petri dishes and allowed to solidify.

In contrast, TCBS Agar preparation involved dissolving 88.1 g of dehydrated medium (B040) in 1 liter of distilled or demineralized water. The solution was slowly brought to a boil while stirring until fully dissolved. Unlike Nutrient Agar, TCBS Agar does not require autoclaving. After cooling, the medium was maintained at 44ºC to 47ºC in an incubator and poured into sterile Petri dishes, where it was allowed to solidify. The plates were then dried in an incubator with the lids partially removed. The schematic of the TCBS Agar preparation process is shown in Figure 5.

Figure 5 – Schematic representation of the preparation of Petri dishes with culture media.



Source: Author's own design

For both culture media, the water samples were inoculated with both filtered and contaminated water, after 24 hours, in duplicate, using a sterilized nickel loop in the flame of a Bunsen burner, leaving one plate as a control, without inoculation (Figure 6).

Figure 6 – Inoculation of plates with water samples before and after filtration

Source: Author's own figure

The tests were conducted following the standard microbiological protocol, with the plates incubated for 48 hours at 37°C to observe the growth of colonies characteristic of microorganisms.

3.5 Analysis of Results

After performing the physical-chemical and microbiological tests, the results were compared between the water samples before and after filtration. For the physical-chemical tests, comparisons were made of pH, conductivity, temperature, and turbidity readings to verify the efficiency of the ecofilter in improving water quality. These tests were conducted in triplicate, and the results were analyzed considering the mean, standard deviation, and p-value (≥ 0.05) to assess the statistical significance of the findings. For the microbiological tests, the reduction or elimination of *Vibrio cholerae* colonies and the total number of microorganisms present in the samples were observed, evaluating the effectiveness of the filter in reducing the microbial load in the water.

3.6 Data Analysis

The data was analyzed using descriptive statistics and the Water Quality Index (WQI). For the physicochemical parameters (pH, temperature, turbidity, conductivity, and alkalinity), the mean and standard deviation were calculated to understand the changes before and after filtration. The WQI was used to summarize the overall water quality, comparing untreated and filtered water.

In terms of microbiological analysis, the reduction in pathogen presence, specifically fecal coliforms and *Vibrio cholerae*, was calculated as a percentage difference between pre- and post-filtration samples.

The data presented in tables provides sufficient evidence to answer the research question, clearly demonstrating the improvement in water quality through the use of the ecofilter.

4. RESULTS

The tests on the water samples from the Barra Nova River revealed significant findings regarding the effectiveness of the ecofilter in improving the water's quality. The tests on the water samples from the Barra Nova River showed that the water temperature before filtration was on average 34ºC, while after filtration, it remained around 24ºC. This change occurred because the water, although collected from the surface and the city temperature was around 38ºC, was exposed to an air-conditioned environment in the laboratory. After approximately 10 minutes, the water temperature stabilized around 24ºC, aligning with the ambient temperature.

Before filtration, the river water appeared muddy with brownish tones, making it opaque. The use of filter paper for pre-filtration removed larger particles, but fine particles remained suspended, keeping the water opaque. After passing through the ecofilter, the water became more translucent, showing a significant improvement in clarity, which highlights the effectiveness of the filter in removing smaller suspended impurities. The comparative images of the water before and after filtration are shown in Figure 7.

Figure 7 – Comparative image of water before and after filtration by the ecofilter.

Source: Author's own figure

The pH of the water before filtration was 5.5, which is acidic. After filtration, the pH increased to 6.0, suggesting a slight neutralization of the acidity. However, the pH was still below the ideal value of 7.0. The filter's ability to increase the pH can likely be attributed to the alkaline materials present, such as coconut shell and activated carbon, known for their neutralizing properties (Sujiono et al., 2023).

In terms of conductivity, the river water had a conductivity of 0.821 µS/cm before filtration, which decreased to 0.219 µS/cm after filtration. This indicates a reduction in the presence of dissolved ions, likely due to the adsorption properties of activated carbon and the coconut shell (Santos et al., 2020; Leite & Gomes, 2021). Additionally, the filtered water had an alkalinity value of 45 mg/L of $CaCO_3$, which is within acceptable standards for drinking water. In contrast, the unfiltered water had a much higher alkalinity of 120 mg/L, suggesting contamination from pollutants.

Table 1 presents the detailed physical-chemical characterization data for the water samples, including temperature, transparency, pH, and conductivity before and after filtration.

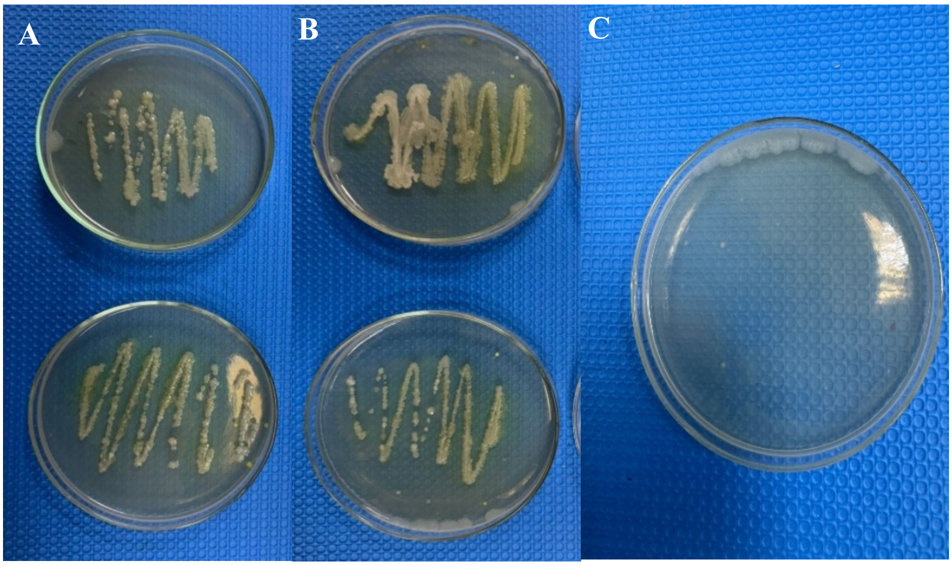
Table 1 – Physical-Chemical Characterization Data

Parameter	Distilled Water	River Water (Unfiltered)	River Water (Filtered)
Temperature (ºC)	23.0 ± 0.09	34.0 ± 0.06	24.0± 0.06
Transparency	Transparent	Brownish turbid water	Transluced
pH	6.5 ± 0.2	5.5 ± 0.2	6.0 ± 0.2
Conductivity (µS/cm)	0.264 ± 0.02	0.821 ± 0.2	0.219 ± 0.03

Source: Author's own data; *p*-value (≥ 0.05).

The microbiological results further complement the physical-chemical findings. The Nutrient Agar test revealed no significant difference in bacterial growth between the filtered and unfiltered water samples, indicating that the ecofilter was not able to remove all microorganisms present. This result is shown in Figure 8.

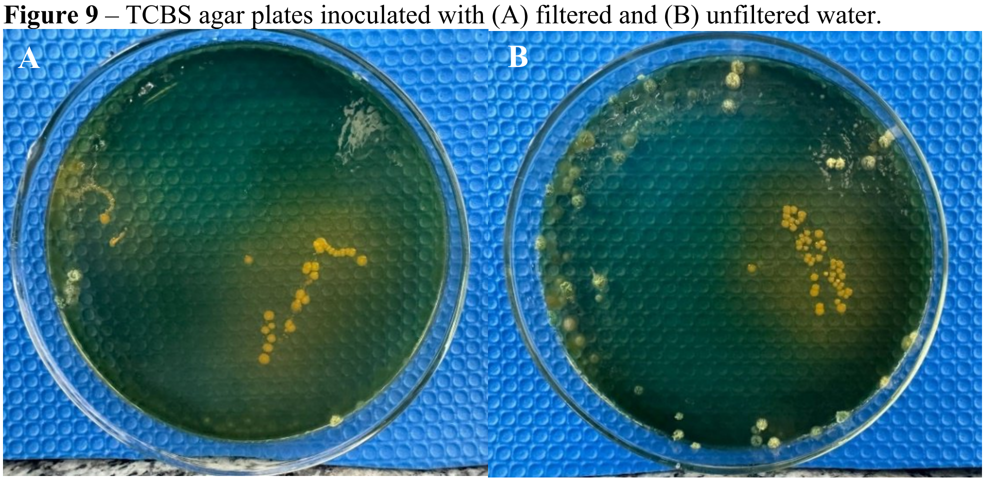
Figure 8 – Nutrient agar plates inoculated with (A) filtered river water, (B) unfiltered water, (C) and the control plate.



Source: Author's own data

The TCBS Agar test, used to detect pathogenic microorganisms, revealed that the filtered water had fewer bacterial colonies, particularly the yellow colonies characteristic of *Vibrio cholerae*, a pathogen associated with fecal contamination. This result is illustrated in Figure 9. The unfiltered water plates, however, showed both yellow and whitish colonies, suggesting the presence of additional pathogenic microorganisms, such as other *Vibrio* species or *Escherichia coli*.

Figure 9 – TCBS agar plates inoculated with (A) filtered and (B) unfiltered water.



Source: Author's own data

5. DISCUSSION

The stability of the water temperature before and after filtration indicates that the ecofilter did not have a significant impact on the temperature, which was primarily influenced by the environmental conditions, such as the air-conditioned laboratory setting. This result aligns with the GLOBE Hydrosphere Protocol (Globe, 2024), which states that filtration typically does not alter the water temperature unless influenced by external factors. Therefore, it can be concluded that the ecofilter did not affect the water's thermal characteristics, ensuring that the filtration process did not interfere with other water quality parameters that could be influenced by temperature changes.

The improvement in the water's transparency after filtration is a clear indication of the filter's efficiency in removing suspended particles. As the GLOBE Protocol notes, turbidity is a key indicator of water quality, and the increase in water clarity after passing through the ecofilter confirms that it effectively reduced turbidity (Globe, 2024). The difference in water clarity before and after filtration is shown in Figure 7.

The slight increase in pH from 5.5 to 6.0 after filtration shows that the ecofilter was able to neutralize some of the water's acidity. However, the pH still fell below the ideal level for drinking water (6.5 to 8.5). The increase in pH can be attributed to the filter materials, particularly the coconut shell and activated carbon, which have alkaline properties capable of neutralizing acidic water (Sujiono et al., 2023). The result suggests that while the ecofilter does improve pH, further modifications may be needed to bring the pH closer to the ideal level for consumption.

The reduction in conductivity from 0.345 µS/cm to 0.219 µS/cm demonstrates the ecofilter's ability to remove some dissolved ions. However, the conductivity of the filtered water remains higher than that of distilled water, suggesting that the ecofilter was not entirely effective in removing all dissolved ions. This indicates that while the filter was successful in removing some ionic compounds, others, particularly water-soluble ions, may not be as easily adsorbed by the materials in the filter (Shinzato et al., 2018).

Finally, the change in alkalinity between the unfiltered and filtered water supports the effectiveness of the ecofilter. The filtered water's alkalinity of 45 mg/L of $CaCO_3$ is within the acceptable range for potable water, while the unfiltered water had a higher alkalinity of 120 mg/L, suggesting contamination from pollutants. This reduction in alkalinity indicates that the ecofilter can help balance the water, making it more suitable for consumption (D'Antoni, 2024).

Despite reducing the visible particulate matter, the filter did not significantly affect the microbial load, likely due to the broad growth support of Nutrient Agar, which promotes the growth of a wide variety of microorganisms.

The reduction in the number of bacterial colonies in the filtered water, as shown in Figure 8, indicates that the ecofilter was effective in reducing the microbial load, particularly concerning *Vibrio cholerae*. The presence of yellow colonies, characteristic of this pathogen, on the unfiltered water plates suggests that the filtration process helped eliminate a portion of the microbial contamination, specifically targeting *Vibrio cholerae*. However, the continued presence of whitish colonies on the filtered water plates indicates that the ecofilter was not entirely effective in removing all pathogenic microorganisms, such as other *Vibrio* species or *Escherichia coli*.

These microbiological results suggest that while the ecofilter reduced some of the pathogenic microorganisms, it was not entirely effective in eliminating all of them, particularly those that remain viable after filtration. This finding aligns with previous studies, which highlight the limitations of basic filtration methods in removing all types of microorganisms (Bergey et al., 2012; Glińska-Lewczuk et al., 2026, Madigan et al., 2015).

In summary, while the ecofilter demonstrated significant improvements in water quality, such as reducing turbidity, increasing pH, and removing some microorganisms, its ability to fully neutralize acidity, remove dissolved ions, and eliminate all microbial pathogens remains limited. These findings suggest that the ecofilter is a promising solution for improving water quality, but further refinement may be necessary to optimize its performance, especially regarding pH and microbial contamination.

6. CONCLUSION

This study demonstrated that the developed ecofilter was effective in improving water quality by removing visible contaminants and reducing the growth of pathogenic bacteria, such as *Vibrio cholerae*. The use of sustainable materials, such as mineral charcoal, coconut shell, and PET bottles, provided a viable and effective solution for treating the water from the Barra Nova

River. Furthermore, the GLOBE Program protocols, particularly those related to hydrosphere analysis (pH, conductivity, turbidity), were essential for systematically and participatively monitoring and evaluating water quality.

The application of the Water Quality Index (WQI) further supported the comprehensive assessment of water quality, highlighting its usefulness in tracking improvements and identifying areas requiring attention. The WQI provided a clear, standardized framework to evaluate physical-chemical and microbiological parameters, offering a holistic view of the river's water quality before and after filtration.

While the ecofilter showed significant improvement in water quality, future research could focus on refining the filtration process by testing additional materials and techniques to enhance its ability to remove a wider range of pathogenic microorganisms. Moreover, the inclusion of UV filters or more sophisticated materials could be explored to increase its overall effectiveness.

Engagement with the school community will be necessary to ensure the project's continuity and impact. Workshops, educational materials, and pamphlets with QR codes will facilitate access to information and promote awareness about the importance of preserving water resources. This project can serve as a model for other regions affected by water pollution, encouraging the use of simple and innovative technologies, combined with environmental education and participatory monitoring supported by GLOBE.

The collaboration with a project mentor was key in guiding the research process, providing essential technical insights, and helping to ensure the practical applicability of the ecofilter. Ongoing mentorship can continue to support and inspire similar community-driven initiatives in the future, promoting sustainable water purification solutions on a broader scale.

7. BIBLIOGRAPHY/CITATIONS

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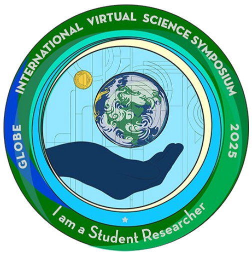
8. OPTIONAL BADGES FOR SCIENTIST SKILLSParte superior do formulário

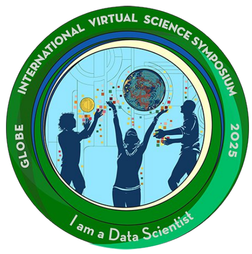
I AM A STUDENT RESEARCHER



In the context of this project, a study was conducted on water quality in the Barra Nova River, with the development of an ecofilter and the application of GLOBE protocols for data collection and monitoring. The involvement in this scientific investigation process justifies the receipt of this badge.

I AM A DATA SCIENTIST

The project involved the collection and analysis of water quality data, utilizing GLOBE protocols, such as the Hydrosphere protocol. Water samples were collected before and after filtration to analyze physicochemical parameters (pH, conductivity, turbidity, etc.) and microbiological parameters (such as the presence of *Vibrio cholerae*). The use of scientific data, conducting calculations, and interpreting results to answer the research questions justify earning this badge.



I AM AN EARTH SYSTEM SCIENTIST

This badge is relevant due to the analysis of the interconnectedness of Earth's systems, including the hydrosphere and biosphere, in the context of water pollution in the Barra Nova River and its impact on public health. GLOBE protocols were applied to monitor essential parameters for ecological balance, such as pH and turbidity, and the impact of sustainable solutions (such as the ecofilter) on environmental improvement was discussed. The application of GLOBE protocols and understanding the interactions between ecological systems supports the relevance of this badge.

I AM A PROBLEM SOLVER

This badge is fitting because the project aims to solve the water pollution problem in the Barra Nova River. An ecofilter was developed using sustainable materials like activated charcoal and coconut shell, with the goal of improving water quality, reducing waterborne diseases, and benefiting public health. The focus on applying practical, accessible solutions to real environmental problems justifies the award of this badge.

I AM A COLLABORATOR

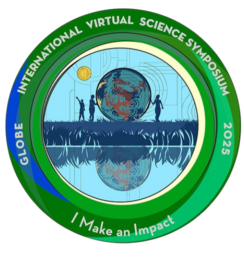
Through effective teamwork and mutual cooperation, the project was successfully executed, with each participant playing an integral role in ensuring the quality and depth of the research. Every team member brought a unique set of skills and strengths, which collectively contributed to the overall success of the work. The collaborative environment fostered the sharing of ideas and experiences, enhancing the learning process and the impact of the research.

- **Salma Sophia Felix dos Santos**: led the research on the theoretical framework and contributed to the environmental awareness section.
- **Fernanda Sofia Soares Santos**: contributed to the development and construction of the ecofilter, focusing on the integration of sustainable materials.
- **Clesylla Yslane dos Santos Ferreira**: worked on the data collection and analysis of water quality parameters using GLOBE protocols.
- **Raysla Yanne Almeida do Nascimento**: assisted in gathering water samples and conducted microbiological analysis.
- **Thaynara Mayane Fernandes de Souza**: contributed to the preparation of educational materials and the dissemination of findings to the local community.
- **Alaine Maria dos Santos Silva**: coordinated the overall project logistics, ensuring smooth communication and collaboration between all team members.

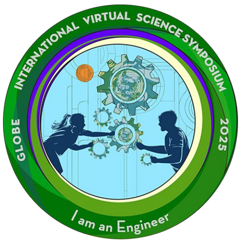
In this project, each participant demonstrated effective collaboration and played a crucial role in the development, data collection, and analysis processes, ultimately contributing to the successful outcome of the research and community involvement

I MAKE AN IMPACT

This badge is granted to projects that make a direct impact on communities. The project had a positive impact on the local community by improving water quality, reducing water-related diseases, and promoting sustainable practices through the implementation of the ecofilter. Additionally, conducting workshops and creating educational materials increased awareness about environmental conservation, reinforcing the positive impact of the project on the community.



I AM AN ENGINEER



This badge is appropriate due to the application of engineering principles in the development of the ecofilter. The use of sustainable materials such as activated charcoal and coconut shell to create a functional and low-cost filtration system reflects the application of engineering knowledge. The optimization of the ecofilter design to address the water pollution problem in the Barra Nova River characterizes the awarding of this badge.