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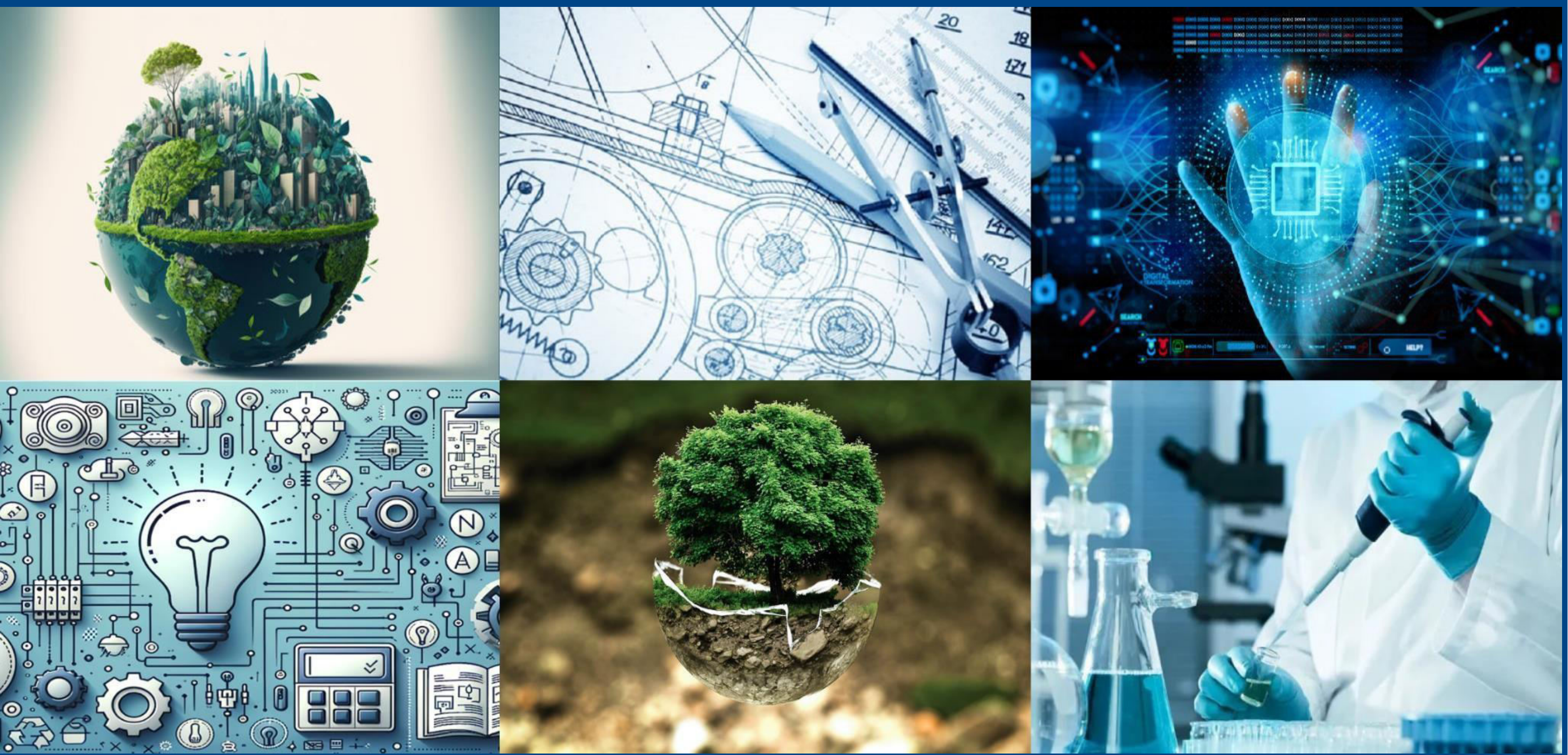

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Comparative Evaluation of Coconut Shell and Rice Husk as Capping Material in Sand Filter

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ABSTRACT: This study evaluates the performance of a rapid sand filtration system enhanced with sustainable, biodegradable capping materials—coconut shell and activated rice husk—to treat water from three sources: tap water, Rakhi Lake, and Nagardhan Lake. Performance was assessed based on Total Dissolved Solids (TDS), pH, turbidity, conductivity, and total hardness.

Post-filtration results demonstrated significant improvements across all parameters. TDS levels for tap and Nagardhan Lake water were reduced to the acceptable range of 300–500 ppm. pH levels consistently neutralized within the 6.5–7.5 range. Turbidity was successfully lowered to safe levels (0–10 NTU) for all lake samples. While conductivity decreased across all sources, Nagardhan Lake achieved the standard 200–800 µS/cm range. Furthermore, total hardness was effectively reduced, transitioning all samples from "hard" to "moderately hard" (below 200 mg/L).

The findings confirm that utilizing coconut shell and activated rice husk as capping media significantly enhances purification efficiency. This research underscores the practical and environmental benefits of integrating agricultural byproducts into water treatment, offering a low-cost, eco-friendly solution for improving water quality in diverse settings.

KEYWORDS: Rapid sand filtration, coconut shell, activated rice husk, turbidity removal, total dissolved solids, pH level, conductivity, total hardness, sustainable water treatment, biodegradable materials, water quality improvement.

I. INTRODUCTION

The global pursuit of sustainable development is inextricably linked to the provision of clean and safe drinking water. As one of the most critical challenges facing modern society, water security is currently under siege from rapid urbanization, intensive industrialization, and unprecedented population growth. These factors have exerted immense pressure on existing freshwater resources, leading to the depletion of quality sources and the contamination of others. Consequently, there is an urgent and evolving need to develop and implement water treatment technologies that are not only effective in removing contaminants but also economically viable and environmentally sustainable.

Among the established methods of water purification, Rapid Sand Filtration (RSF) remains a cornerstone of municipal and industrial water treatment. Its widespread adoption is attributed to its high efficiency in removing suspended solids, reducing turbidity, and mitigating microbial risks. The fundamental mechanism of a rapid sand filter involves a multi-layered bed of granular media. As raw water percolates through these layers, impurities are removed through a combination of physical straining, sedimentation, and adsorption.

A critical, yet often overlooked, component of this system is the capping material—the uppermost layer of the filter bed. As the initial point of contact for influent water, the capping layer significantly influences the hydraulics and filtration kinetics of the entire system. It serves as a primary barrier that determines the initial removal of larger particles and dictates operational parameters such as the filtration rate, the rate of head loss development, and the overall length of the filter run.

The Shift Toward Sustainable Materials

Traditionally, filtration systems have relied on conventional materials such as anthracite, coarse sand, and gravel. While effective, the procurement and processing of these materials can be energy-intensive and costly. In the contemporary context of "green engineering," researchers are increasingly pivoting toward agricultural byproducts as renewable alternatives. Utilizing waste materials like coconut shells and rice husks aligns with the principles of the circular economy, transforming agricultural "waste" into valuable functional assets for water treatment.

Coconut shell is characterized by its high carbon content, exceptional mechanical strength, and naturally porous structure. Its rough surface area is particularly adept at trapping colloidal matter, making it a promising candidate for enhancing turbidity removal. Conversely, rice husk, a silica-rich byproduct of the milling industry, offers unique hydraulic advantages. Being lightweight and fibrous, it possesses a low bulk density that may contribute to reduced resistance to flow, thereby minimizing head loss—a common bottleneck in filtration operations.

The 21st century is known to be the age of digital world. There has been the adoption of computers to a great extent. Today without computers and Internet one cannot survive as we are dependent on these machines for almost all our work. Taking into consideration starting from home to education till banking and even corporate functioning everything has now been automated to computers. Computers contain all our important data in the digital format. With this the need to store the digital data has increased and virtual environment has replaced the physical storage for storing all our credentials as shown in Fig. 1. The most devastating challenge of cloud is to prevent the unauthorized deletion of the stored data on cloud because one can easily delete the stuff without any proper authorization. The data deletion is totally dependent on deletion of nodes that are pointing to some information in Virtual Machine.

II. LITERATURE REVIEW

[1] Chinmay Bhavsar (2024) used a rapid sand filter with a sand bed and gravel layer to remove suspended materials. Anthracite coal is used as a capping material, but crushed coconut shells can be a sustainable and effective substitute. An experimental setup using an acrylic filter column with gravel, sand, and crushed coconut shells traditionally showed promising results. The coconut shells enhanced filter performance, improving efficiency and reducing issues like mud ball formation. They also effectively removed organic compounds and reduced BOD. Dual media filters with coconut shells are recommended for water treatment plants due to their superior turbidity removal (up to 85%) and reduced head loss.

[2] Chaudhari Snehal (2017) stated that conventional filtration, a long-standing method, effectively treated a wide range of raw water turbidity through thorough 7 clarification following coagulation and flocculation. Properly operated clarification removes most suspended solids, ensuring that filtered water turbidity does not exceed 40-50 Nephelometric Turbidity Units (NTU). While slow sand filters are advantageous for rural water treatment, their significant space requirement of approximately 2000m² makes them costly for future water demands and associated equipment needs. Hence, rapid sand filtration is preferred, comprising an enclosure tank, underdrainage system, base material, sand filter media, and appurtenances, ensuring efficient water purification. The size of the filter is designed to be 30x45 cm, with a capacity of 20 liters. Coarse aggregate, fine aggregate, and crushed coconut shell provide depths of 8 cm, 5 cm, and 5 cm respectively. The rapid sand filter proves to be very effective, resulting in colorless, odorless water with 96% turbidity removed. The pH is moderate, and the water is moderately hard. The filter is economical and durable.

[3] Bihade Abhishek (2022) faced challenges with the Rapid Sand Filters (RSF) in meeting increased demand, but capping materials like coconut shells can enhance filtration. This study used a filter unit with a gravel bed, sand layer, and crushed coconut shell layer to test its effectiveness. River water was passed through the filter, and effluent samples were collected every hour for 8 hours. Results showed a significant reduction in turbidity (up to 90%), total solids (up to 89%), and BOD, demonstrating the effectiveness of coconut shells as a filter media in removing fine particles, organic compounds, and improving water quality.

[4] Kamatagi Poornima (2022) rapid sand filter was commonly used in surface water treatment but faced overloading issues due to increased demand. Capping existing filters with materials like coconut shells can enhance performance. This study assesses coconut shell as a capping medium in a rapid sand filter. The experimental setup consists of a gravel bed, sand layer, and crushed coconut shell layer. Lake water was 5 passed through the filter, and influent and

effluent samples were collected every 2 hours to test for turbidity, pH, total solids, BOD, and COD. Results showed the filter with coconut capping performed well, achieving low turbidity (4.9 NTU) and high total solids removal (93%). The study demonstrates the effectiveness of coconut shell as a capping material in improving filtration rates and water quality.

[5] Jain Priyesh (2018) stated that Rapid Sand Filters (RSF) were commonly used in water treatment but could become overloaded due to increased demand. Capping with materials like crushed coconut shells can enhance filtration quality. A study used a layered filter with gravel, sand, and coconut shells to assess filtration efficiency. Results showed significant improvements Up to 90% reduction in turbidity, 89% decrease in total solids, Considerable reduction in pH and BOD, Notable decrease in color intensity. Using coconut shells as a filter media effectively removes organic compounds, demonstrating its efficiency in improving water quality.

[6] Shinde Amey (2021) stated that water was essential for survival, and slow sand filtration was key method for providing clean water, especially in rural areas. This process uses biological mechanisms to remove particles without chemicals. In India, sand filters are commonly used and capping them with materials like coconut shell or coal enhances their performance. An experiment with a filter unit consisting of gravel, sand, and coconut shell showed that coal-capped filters were more effective in removing hardness and total dissolved solids. However, filtration efficiency decreased at higher flow rates, and slow sand filters have limitations such as lower flow rates and the need for periodic media replacement. Combining coconut shell and coal improved the removal of turbidity and dissolved solids.

[7] Venkateswarlu Dumpa Dr (2021) conducted a study that explored using coconut shells as a capping material in rapid sand filters to enhance filtration quality. Lake water was filtered through a layered system including gravel, sand, and crushed coconut shells. Effluent samples were collected hourly and tested for turbidity, pH, total solids, and BOD. Results showed a significant reduction in Total solids: up to 89%, Turbidity: nearly 90%, BOD: efficient removal, Color intensity: considerable reduction, pH: changed during filtration. The coconut shell capping material demonstrated high efficiency in removing fine particles and organic compounds, improving water quality.

[8] Kumar Hemanth (2019) had water samples from the filtration unit were lab-tested 6 at 15-minute intervals for pH, total solids, fluoride, and nitrate, ensuring continuous water quality assessment. The filtration system effectively removed contaminants, improving water quality. Rapid Sand Filters are common but face challenges, while Multimedia filters offer higher rates yet are limited in India. Levels A proposed study explores using coconut shell to enhance bacterial filtration. Test results showed a slight increase in pH, significant fluoride removal, and reduced nitrate concentration, demonstrating effective removal of solids, fluoride, and nitrate, and highlighting the filtration system's effectiveness.

[9] Upase Prapti (2022) study explored using coconut shell as a capping material in filtration to improve water treatment. A filter unit was set up with a gravel bed, sand layer, and crushed coconut shell layer to test its effectiveness. Lake water was passed through the filter, and effluent samples were taken every hour to test for turbidity, pH, total solids, and BOD. Results showed high efficiency in filtration, reduced color intensity, and altered pH, with effective removal of BOD. Using coconut shell as a capping material allows for higher filtration rates without compromising quality, making it a useful solution for overloaded conventional Rapid Sand Filters, and also imparts a taste to the water.

[10] Sable Ranjeet (2018) stated that Rapid Sand Filters (RSF) were commonly used in water treatment, but could become overloaded. Capping with coconut shells can enhance filtration. A study used a layered filter with gravel, sand, and coconut shells, achieving up to 90% reduction in turbidity, 89% decrease in total solids, a reduction in pH and BOD, decrease in color intensity. Coconut shells prove effective in removing organic compounds, improving water quality.

[11] Kapgate Sudhir (2018) stated that the Rapid Sand Filter (RSF) was a scaled-down version of traditional slow sand filters, which were used for household water treatment. It consists of layers of sand and gravel, capturing suspended materials and requiring periodic cleaning. A practical model of an RSF with a coconut shell-capped dual media filter was developed, using standardized aggregates and a trapezoidal-shaped column. The filter efficiently eliminates impurities, improving water quality and transforming turbid water into clean water suitable for consumption. The study recommends adopting RSF with coconut shells as capping media for superior water treatment, based on findings from comprehensive investigations.

Conclusion of Literature Review: This study demonstrates the potential of coconut shell and rice husk as sustainable and efficient capping materials in rapid sand filters for water treatment. The results show that both materials are effective in removing turbidity and maintaining hydraulic performance, with coconut shell exhibiting higher turbidity removal efficiency and rice husk showing lower head loss. The use of these natural and biodegradable materials offers a promising alternative to traditional capping materials, addressing environmental concerns and reducing costs. The findings of this research contribute to the development of innovative and sustainable water treatment solutions, promoting access to clean and safe drinking water while minimizing environmental impact. Further research and pilot-scale applications are recommended to validate and optimize the use of coconut shell and rice husk in rapid sand filters for real-world water treatment applications.

III. METHODOLOGY

3.1 Characterization of Material:

The filtration system uses four primary media layers; each carefully prepared before use:

- **Gravel (Supporting Media):** Coarse aggregate passing through a 9.5mm sieve and retained on a 4.75mm sieve. It provides physical support and is washed and oven-dried before placement.

Fig. 3.1 Gravel

- **Sand (Filter Media):** River sand passing through a 600-micron sieve. It is washed, sun-dried, and oven-dried to remove silt and organic material.
- **Crushed Coconut Shell (Capping Media):** Shells are manually crushed using a rammer to an effective size of 1.91mm. They are thoroughly cleaned and oven-dried for 24 hours.

Fig. 3.2 Coconut Shell

- **Activated Rice Husk (Capping Media):** Raw rice husk is washed with distilled water and dried at 60°C. It is then carbonized in an electric furnace at 500°C to 700°C for two hours to produce rice husk carbon.

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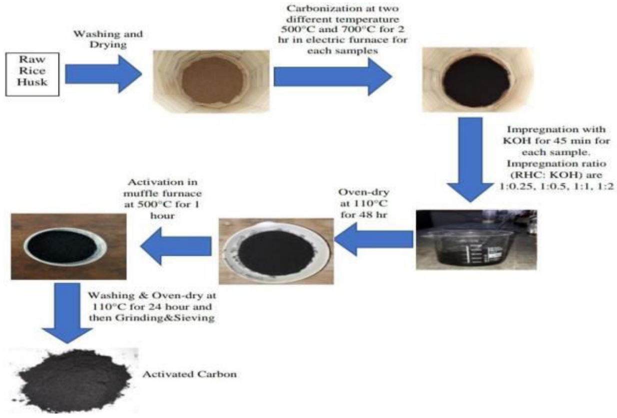

Fig. 3.3 Flow diagram of ACs production procedure

3.2 Experimental Program:
Glass Model with Materials Filling
The glass model of water filtration shows various layers of materials such as gravel, sand, activated rice husk, and crushed coconut shell. Each material layer is 20 cm thick, making a total of four layers in the model. The top layer is a gravel bed, which helps to keep the other materials in place and prevents them from floating when water is added during the filtration process.

Fig. 3.4 Tank showing filling of material

3.3 Steps to use the portable multiparameter water quality meter:
1. Preparation:
The user should first get familiar with the appearance that usually consists of a host, a sensor and a display. The host is the core component for controlling and processing measurement data, the sensor is used to detect water quality parameters, and the display is used to display measurement results and related information.
Charge the device or install the battery: Make sure the device has been charged or a new battery has been installed to ensure the normal use of the device.
Connect the water sensor: Turn on the host and connect the sensor to the host according to the device manual.

Clean the cuvette: Prepare some cleaning supplies, such as an ultrasonic cleaner or a special detergent, to keep the outside and inside of the instrument cuvette clean. After washing, rinse with pure water and wipe off the water and fingerprints on the cuvette with soft cloth.

Fig. 3.5 Multiparameter

2. Calibrate the Multiparameter Water Quality Meter
Perform calibration: Immerse the water sensor in the calibration solution, wait a while for the instrument to stabilize, and then perform the calibration according to the instrument display or instructions.

3. Prepare Water Samples
Collect water samples: Collect the water samples to be tested and put them into a clean container. Make sure the container is clean and free of contamination. You can choose to use a sterile container.
Water sample processing: For non-clear and transparent water bodies, a microporous membrane filter can be used to filter the water sample required for testing. 1~2mL of the initial filtrate should be discarded during filtration, and the filtrate obtained is used as the water sample to be tested.

4. Start Testing
Zero calibration: If the instrument needs to be zeroed, perform the zero-calibration operation according to the instructions in the manual, such as using a colorimetric bottle to take 10ml of colorless and clear water sample to be tested and put it into the testing instrument for zeroing.
Test water sample: Immerse the sensor in the water sample, ensure that the sensor is in full contact with the water sample, and avoid the presence of air bubbles. According to the requirements of the instrument, wait for a period for the instrument to stabilize and measure.
Record the results: Once stable, the instrument will display or output the corresponding test results, such as pH value, dissolved oxygen concentration, turbidity, etc.

5. Interpret the Results
Refer to the required water quality standards or requirements and interpret the test results. Compare the difference between the measured value and the standard value to determine whether the water quality meets the requirements.

6. Cleaning: After use, clean the water sensor and multiparameter water quality meter in time according to the instructions in the instruction manual, ensure that the sensor and instrument surfaces are clean and remove any residues that may affect the next test.

Tests Performed on Water
- pH
- Total dissolved solids (TDS)
- Turbidity
- Conductivity
- Hardness

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IV. RESULTS AND DISCUSSION

Initial Sample Testing Results:

Sr. No	Parameters	Standard Value	Tap Water	Rakhi Lake	Nagardhan Lake
1	pH	6.5 to 8.5	7.79	7.97	7.34
2	TDS	300 to 500 PPM	532	669	630
3	Turbidity	0-10 NTU	0	22	24
4	Conductivity	200-800 µS/cm	1065	866	840
5	Total Hardness	0- 200 mg/L	121	125	142

Table No. 3.1 Initial sample testing results

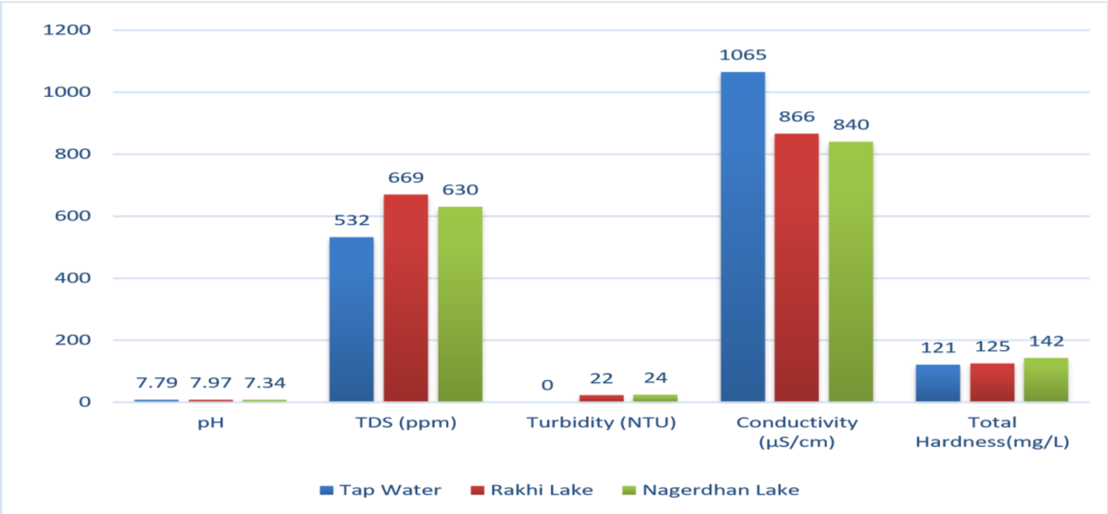

Chart 3.1 Bar graph of Initial sample testing results

Final Sample testing results (Gravel, Sand, Rice Husk & Coconut shell):

Sr. No	Parameters	Standard Value	Tap Water	Rakhi Lake	Nagardhan Lake
1	pH	6.5 to 8.5	7.56	7.16	6.98
2	TDS	300 to 500 PPM	443	503	469
3	Turbidity	0-10 NTU	0	7	10
4	Conductivity	200-800 µS/cm	850	780	748
5	Total Hardness	0- 200 mg/L	97	110	104

Table No. 3.2 Final sample testing results

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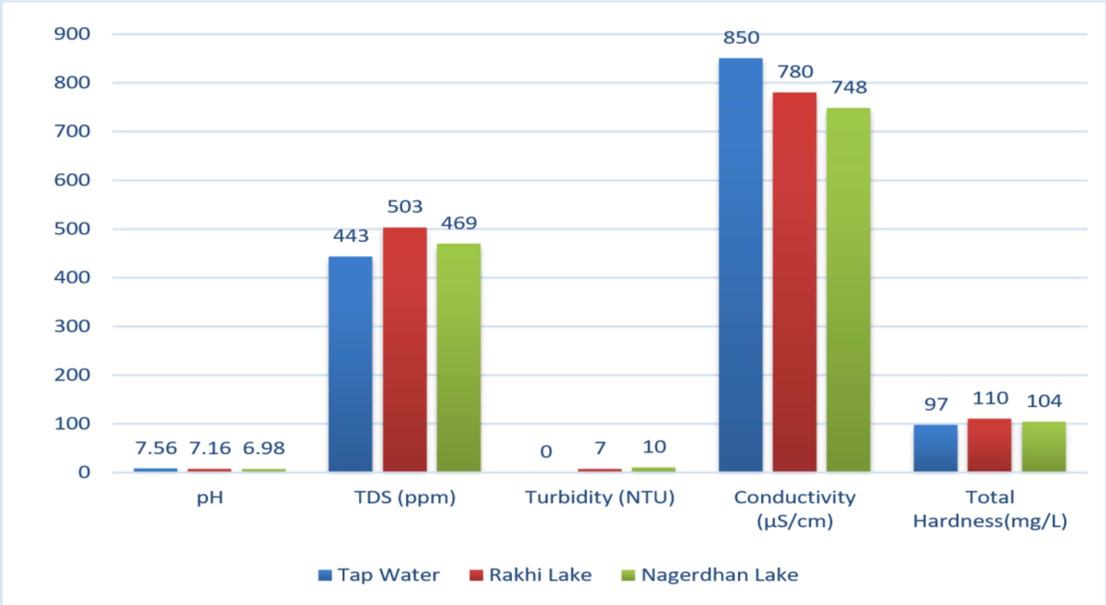

Chart 3.2 Bar graph of Final sample testing results

Comparative Analysis:
pH Test:
The pH testing of water samples before and after sand filtration, using coconut shell and activated rice husk as capping materials, showed a consistent decrease in pH levels. Tap water dropped from 7.79 to 7.56, Rakhi Lake water from 7.97 to 7.16, and Nager Dhan Lake water from 7.34 to 6.98. While tap and Rakhi Lake water moved closer to the neutral pH range of 6.5–7.5, Nager Dhan Lake water became slightly acidic. This suggests that the enhanced sand filtration system effectively reduces water alkalinity and adjusts pH levels toward acceptable standards, though the outcome varies based on initial water quality.

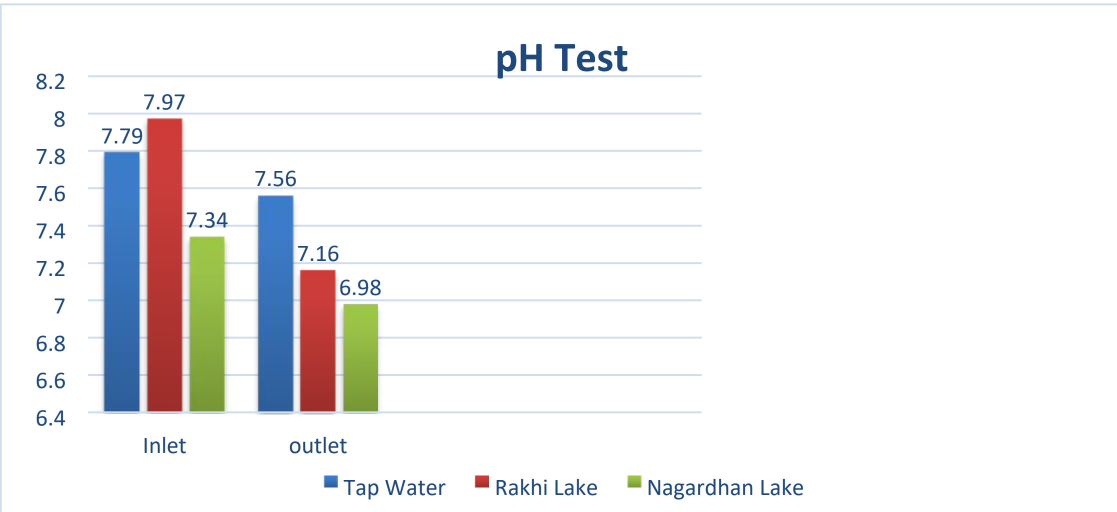

Chart 3.3 Bar graph of pH test

Total Dissolved Solids (TDS) Test: This test shows a clear reduction in TDS levels after sand filtration using coconut shell, activated rice husk, and gravel. Tap water decreased from 532 to 443 ppm, Rakhi Lake from 669 to 503 ppm, and Nager Dhan Lake from 630 to 469 ppm. According to the acceptable TDS range of 300–500 ppm, only the filtered tap water and Nager Dhan Lake water meet the standard, while Rakhi Lake remains slightly above. This indicates the filtration method is effective in lowering TDS, though further treatment may be needed for sources with higher initial levels.

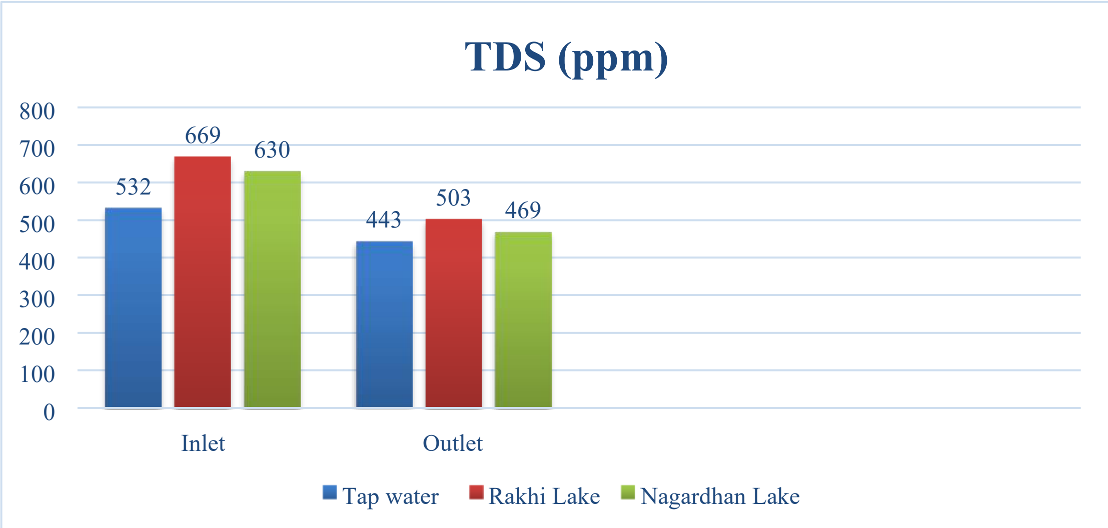

Chart 3.4 Bar graph of TDS (ppm)

Turbidity Test: Test on water samples, conducted before and after the sand filtration process using capping materials such as coconut shell and activated rice husk, along with sand and gravel as standard filtration materials, shows a significant improvement in water clarity. For tap water, both the initial and outlet turbidity readings were 0 NTU, indicating no turbidity and therefore no change. Rakhi Lake water showed a reduction from 22 NTU to 7 NTU, which represents a turbidity removal of approximately 68.18%. Similarly, Nager Dhan Lake water showed a decrease from 24 NTU to 10 NTU, resulting in a removal efficiency of around 58.33%. According to the standard turbidity range for safe water quality, which is between 0 and 10 NTU, both lake water samples meet the acceptable limit after filtration. This comparative analysis highlights that the sand filtration system, enhanced with coconut shell and activated rice husk, is effective in significantly reducing turbidity and improving water quality, particularly for lake water with high initial turbidity levels.

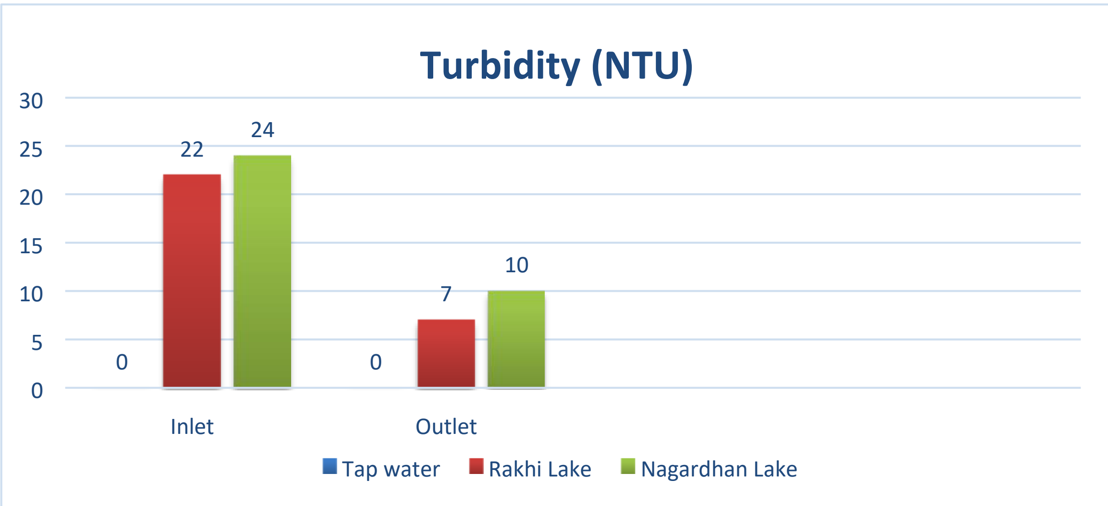

Chart 3.5 Bar graph of turbidity (NTU)

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Conductivity: The conductivity test on water samples, conducted before and after the sand filtration process using capping materials such as coconut shell and activated rice husk along with sand and gravel as standard filtration materials, reveals a reduction in conductivity levels across all sources. For tap water, the conductivity decreased from 1065 µS/cm to 850 µS/cm. In the case of Rakhi Lake water, it reduced from 866 µS/cm to 780 µS/cm, while Nager Dhan Lake water showed a decrease from 840 µS/cm to 748 µS/cm. According to standard water quality guidelines, the acceptable conductivity range is between 200–800 µS/cm. Based on these standards, only the outlet water from Nager Dhan Lake falls within the acceptable range after filtration, while the outlet water from tap water and Rakhi Lake still slightly exceeds the upper limit. This comparative analysis indicates that the sand filtration process, enhanced with coconut shell and activated rice husk, is effective in lowering the conductivity of water, though the extent of reduction varies with the initial conductivity levels

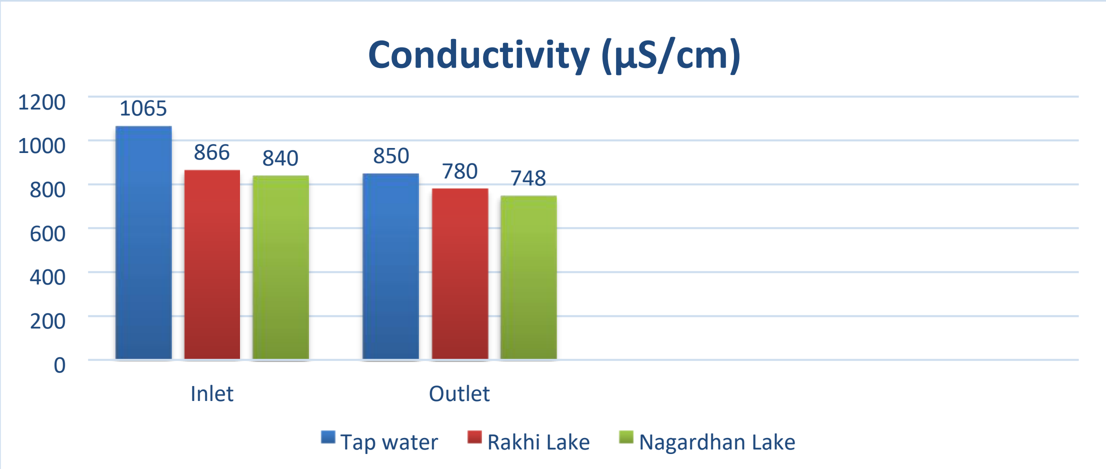

Chart 3.6 Bar graph of Conductivity (µS/cm)

Total Hardness Test: Test on water samples before and after sand filtration— enhanced with coconut shell and activated rice husk—shows a clear reduction in hardness levels. Tap water hardness dropped from 121 mg/L to 97 mg/L, Rakhi Lake from 125 mg/L to 110 mg/L, and Nager Dhan Lake from 142 mg/L to 104 mg/L. Initially classified as "hard" water, all samples shifted to the "moderately hard" category post-filtration. As the acceptable standard for total hardness is 0–200 mg/L, all results remained within safe limits. This demonstrates the effectiveness of the enhanced sand filtration method in improving water quality by reducing hardness to more manageable levels.

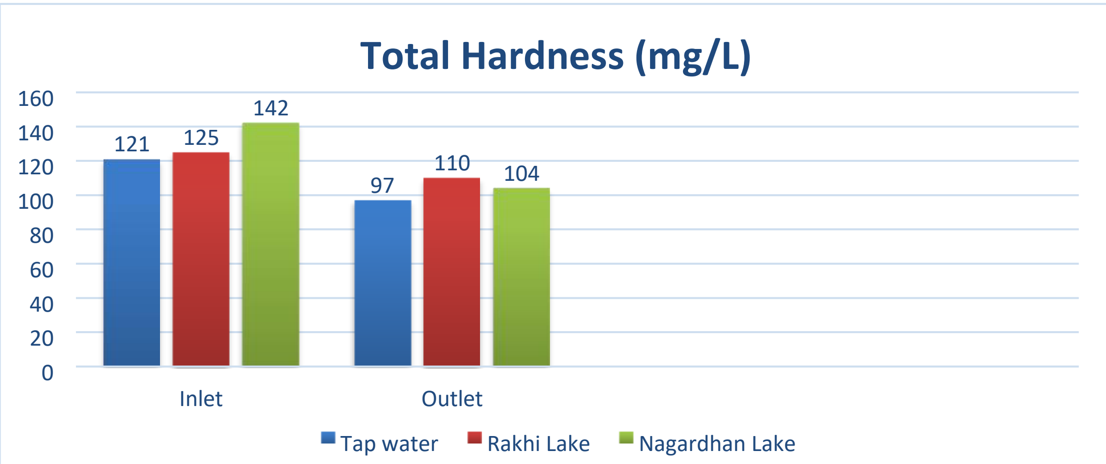

Chart 5.3.5 Bar graph of total hardness (mg/L)

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V. CONCLUSION AND FUTURE WORK

In this paper, we have proposed the significant potential of utilizing low-cost, sustainable materials to enhance traditional water treatment methods. By integrating **coconut shell and activated rice husk** as capping agents within a sand and gravel filtration system, the process achieves a comprehensive improvement across multiple water quality indicators.

The study demonstrates that the system effectively buffers **pH levels** toward a neutral range (6.5 to 7.5) and noticeably reduces **Total Dissolved Solids (TDS)**, bringing both tap and Nager Dhan Lake water into alignment with acceptable standards. Furthermore, the filtration media showed a high efficiency in removing suspended particles, resulting in a substantial drop in **turbidity** and a marked improvement in water clarity.

While the system successfully lowered **conductivity** and transitioned water from a "hard" to a "**moderately hard**" classification, some samples remained slightly above the ideal conductivity limits. This suggests that while the media—particularly the activated rice husk—possesses strong adsorptive properties, its performance is ultimately tied to the initial contamination levels of the source water. Consequently, while this bio-enhanced filtration is a highly practical and efficient solution for rural or resource-limited settings, additional treatment stages may be necessary to consistently meet the most stringent drinking water standards.

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