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Experimental Study of Rapid Sand Filter Using Coconut Shell as Capping Material

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Abstract: *This study investigates the feasibility of using coconut shell as a capping material in quick sand filtration systems in response to the increasing need for effective water treatment techniques. The purpose of the experiment is to determine how coconut shell affects the turbidity, hardness, pH, total dissolved solids (TDS), and total suspended solids (TSS) of the water. To evaluate the efficacy of the filtration process made better by the presence of coconut shell, the research entails thorough testing and analysis. Promising outcomes are revealed by the investigation through methodical experimentation carried out under controlled conditions. The maintained water quality standards are demonstrated by the filtered water's pH levels, which stay within allowable bounds.*

Moreover, notable decreases in turbidity, hardness, TDS, and TSS are noted, indicating effective impurity removal from the water. The results demonstrate coconut shell's potential as an affordable and environmentally friendly capping material for quick sand filters. The abundance, biodegradability, and affordability of this natural material make it a desirable choice for improving filtration procedures in water treatment plants. Through the use of renewable resources, coconut shell can enhance water treatment efficiency while simultaneously promoting environmental sustainability.

Keywords: Rapid sand filter, Coconut shell, Capping material, Water treatment, filtration efficiency, pH, Turbidity, Hardness, TDS, TSS

I. INTRODUCTION

In water treatment facilities, rapid sand filters are frequently used for tertiary treatment, which removes leftover materials following sedimentation. There are several layers in a fast sand filter; gravel at the bottom supports the layers above it. A sand bed serves as the filter material and is positioned above the gravel.

Crushed coconut shell fragments are one possible environmentally friendly replacement. Many tropical and subtropical regions are home to the widespread coconut crop, which produces a substantial biomass waste stream of shells once the flesh and water are extracted Traditionally, the capping material above the sand bed has been a layer of anthracite coal. Crushed coconut shells, on the other hand, work well as a substitute capping material, according to recent tests. A common agricultural waste produced in tropical nations is coconut shells. This agricultural waste can be reused in an environmentally beneficial way by using them as capping material.

Objective of the project

Our goal is to attain higher filtering quality. We are interested in developing a more effective and cost-effective alternative to the traditional filter design that can eliminate the drawbacks of the widely used RSF.

Following are the objective of the proposed study:

- To suggest more efficient filter design.
- To remove turbidity effectively.
- To increase filtration rate and run time.
- To reduce backwashing requirement.

- To provide economical method for purification of water.
- To compare performance of Dual Media Filter over conventional rapid sand filter.

II. LITERATURE SURVEY

2.1 MOHAMMAD ABDOLLAHI.ET AL. (2014) Studied two pilot filter columns. One is conventional RSF and other is capped RSF. Conventional rapid sand filter and capped rapid sand filter are compared. limiting head loss-1.80 to 3.0m, depth of sand - 60cm, depth of gravel support -40cm, etc. A rapid sand has many advantages like easy operation, more filtration rate, easy backwashing, and output. Due to improper backwashing, major problems shown in the filter media is mudball formation. Stratification of sand media takes place at the time of backwashing process. Filtration process is affected due to the increase in head loss in shorter run time. Capping of rapid sand filter is suggested by the researchers to overcome to these problems. Capping is the process in which upper sand bed layer is replaced with few centimetres of capping material. Capping proves efficient techniques for improving performance of RSF. Capping with PVC granules with 3cm depth gives turbidity removal up to 92%.

2.2 Snehal N. Chaudhari, Kalyani A. Bogawar -2017:Introducing and filter capping for turbidity removal for potable water treatments plant. This paper proposes sand filter sand filter capping technology in which the top portion of a rapid sand filter is replaced with PVC granules in order to achieve the improved performance if introduced in water treatment plants. Improved rapid sand filter for performance enhancement. This paper focuses on cheaper and easily available capping material PVC granules for better operation of rapid sand filtration.

2.3 Er. Mukesh Kumar, Er. Sandeep Pannu [2023] The design of a water treatment plant utilizing SCADA (Supervisory Control and Data Acquisition) technology and coconut shell as a capping material for sand in rapid sand filters is presented in this study. The primary objective of the design is to provide safe drinking water by removing suspended solids, organic matter, and other contaminants from the raw water. The treatment process involves several stages, including coagulation, flocculation, sedimentation, rapid sand filtration, and disinfection. The use of coconut shell as a capping material for sand in rapid sand filters is a novel approach that offers several benefits over traditional sand filters, including increased filtration efficiency and reduced maintenance costs. SCADA technology is utilized to automate the operation of the treatment plant, enabling real-time monitoring and control of the treatment process. The design of the treatment plant is presented in detail, including the sizing and specification of equipment, process flow diagrams, and instrumentation and control systems. The design parameters are based on local water quality standards and are optimized to ensure maximum efficiency and effectiveness of the treatment process. Overall, the proposed design provides an efficient and cost-effective solution for water treatment, utilizing innovative technologies and materials to deliver safe drinking water to the community.

2.4 Alfaj N. Shaikh [2021] A study was done to determine about sand filter these filters are commonly used in conventional water treatment plants. Problems like mud ball formation and unsatisfactory effluents are affecting sand filter beds. It has been found out that dual media and multimedia filters can overcome the limitations of sand filter. Capping materials such as crushed coconut shell and coal is used as a dual media. Design dual media filters capped with crushed coconut shell proves to be more efficient, economical and durable. Three models having capacity of 10 Liter are practiced. All these models consist layers of gravel, sand and capping material of thickness 7cm each. Crushed coconut shell and coal are used as capping material in different models respectively. The water sample was collected from nearby river. The tests which are conducted on sample are pH, Temperature, Total Dissolved Solids, Alkalinity, and Turbidity. The efficiency is based on test results.

III. MATERIALS

Sand:

A fast sand filter's primary filtering material is sand. It usually consists of silica sand that has been carefully graded and has a homogeneous particle size distribution. Sand serves as a physical barrier that allows water to flow through while capturing organic waste, suspended particles, and other contaminants. An important aspect in influencing the RSF's filtering performance is the sand's quality and features, including its particle size, shape, and cleanliness. The sand used in RSFs is selected to have a specific particle size distribution, typically ranging from 0.7 to 1.0 millimeters in diameter.

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Gravel:
A layer of coarser material, such gravel, is frequently layered underneath the sand layer. In addition to supporting the sand bed, this layer works to keep the sand from being carried away during backwashing. Additionally, the gravel layer helps to ensure that water is distributed evenly across the sand base. In the end, the gravel layer plays a critical role in maintaining the stability of the sand bed, minimizing sand loss, and encouraging even water distribution—all of which are essential for the fast sand filter to operate at its best and last a long time. The gravels used in RSFs is selected to have a specific particle size distribution, typically ranging from 6 to 12 millimeter.

Coconut Shell:
When it comes to the sand filters used in rapids, coconut shells have a unique function. Coconut shells are occasionally used as part of the filtering material for making sand filters. Coconut shells' uneven and porous surface structure improves its filtration power. Coconut shells are added to sand filters in rapids to aid in the filtration process by giving particles and contaminants in the water more surface area to attach to. This encourages the efficient removal of impurities, increasing the filtration system's efficiency. The environmentally benign aspect of this filtration technique is enhanced by the sustainable and renewable nature of coconut shells. The coconut shells in the sand filter catch and hold sediments, dirt, and other particles as the water rushes through it quickly. The Coconut Shell used in RSFs is selected to have a specific size distribution, typically ranging from 6 to 8-millimeter.

IV. METHODOLOGY

4.1 Height of the various materials that make up the model:

Gravels: 1.3 Feet
Sand: 0.9 Feet
Coconut Shell: 0.5 Feet
The experimental setup is designed in accordance with the fundamentals of rapid sand filtration. Based on the review of literature, the setup design has been completed. A single filter column is needed for setup. An acrylic filter column measuring 3 feet in length was chosen. The depth of base material and sand media in the filter column are set as they are in a typical quick sand filter. A 15 cm hole is bored from the bottom to allow for sample collection at different times. Within the filter unit, a layer of crushed coconut shell measuring 0.5 feet in thickness, a layer of sand measuring 0.9 feet, and a layer of gravel bed measuring 1.3 feet were distributed as the filter layer. A sizable container holds the water that was collected from the sample stations for a duration of three to four hours. Throughout the test period, there was always 0.5 feet of water above the filter media in the filtration unit. The dispenser, which was positioned above the filtration unit, continually supplied the raw water to the filter. A sample of water was collected for the experiments.

4.2 Sampling Stations

- Ramkunda
- Dasak
- Kapila Sangam
- Ground Water (Hand-pump)

4.3 Test conducted on water sample

pH:
Procedure:
Collect water from the polluted lake and transfer it into a beaker.
Switch on the Ph meter.
Remove electrodes from storage solution and rinse with water.
Bloat with soaked tissue paper.
Standardize the instrument with electrodes immersed in a buffer solution (Acetate buffer Ph = 4).
Rinse, bloat and dry the electrodes to each tie.
Check the Ph on the Ph meter (ph. = 7).

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Rinse, bloat and dry the electrodes.
Standardize the instrument with electrodes immersed in a buffer solution (Ammonium buffer ph. = 10).
Rinse, bloat and dry the electrodes and check the ph. on the ph. meter (ph. = 7).
Dip the ph. electrode in the beaker containing waste water to be tested. Noted the ph.44
Replace the electrodes in the storage solution.

Figure 4.1: pH Meter

Turbidity:
Procedure:
Switch on the Nephelometric turbidimeter and wait for few minutes till it warms up.
Set the instrument at 100 on scale with 40 NTU standard suspension.
In this case, every division on the scale will be equal to 0.4 NTU turbidity.
Shake thoroughly the sample and keep it for some time to eliminate the air bubbles. Take the sample in nephelometric sample tube and put the sample chamber and find out value on the scale.
Dilute the sample with turbidity free water and again read the turbidity.

Figure 4.2: Turbidity Meter

V. RESULTS AND OBSERVATION

1. pH:
Observation table:

Sr. No.	Sample station	Sample Readings	
		23/02/2024 (Conventional RSF)	22/03/2024 (RSF using Capping Material)
1	Ramkunda	7.79	7.57
2	Dasak	7.98	7.16
3	Kapila Sangam	7.23	7.03
4	Ground Water (Hand-pump)	7.24	6.98

Table 1: pH Calculations

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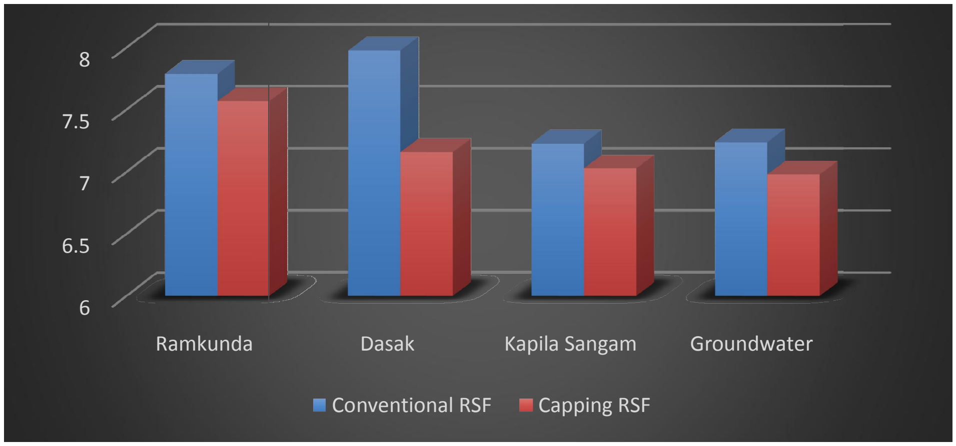
Graph 1: pH Calculations



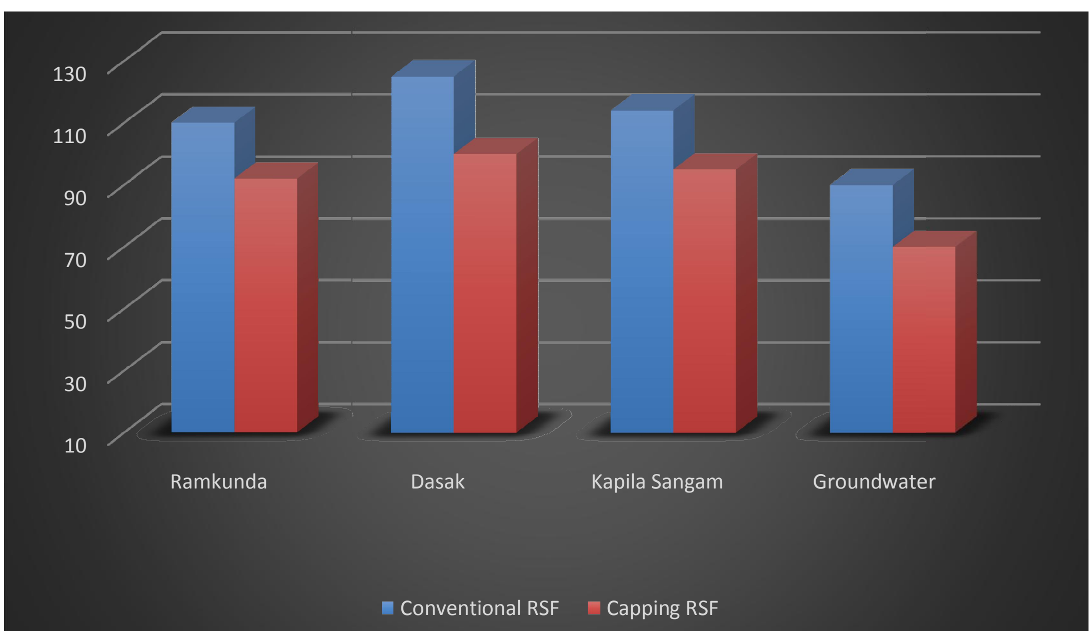
2. Turbidity:

Observation table

Table 2: Turbidity Calculations

Sr. No.	Sample station	Sample Readings	
		23/02/2024 (Conventional RSF)	22/03/2024 (RSF using Capping Material)
1	Ramkunda	110	92
2	Dasak	125	100
3	Kapila Sangam	114	95
4	Ground Water (Hand-pump)	90	70

Graph 2: Turbidity Calculations



VI. CONCLUSION

In addition to the above layers, by capping the extra layer with crushed coconut shells helps in improving the performance of rapid sand filter.

The efficiency of the quick sand filter can be enhanced by topping the extra layer with crushed coconut shells. Dual media filter proves to be better alternative for filtration units in treatment plan.

It facilitates main purpose of turbidity removal up to 85%, twice filtration rate, reduced head loss mud ball formation ,sand leakage.

The reduction in BOD demonstrates the effectiveness with which coconut shell can remove organic compounds.

Based on these results, coconut shell shows promise as a capping material for rapid sand filters in water treatment applications.

VII. ACKNOWLEDGMENT

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