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An Experimental Study on optimizing Wastewater Filtration through Conventional and Capped Rapid Sand Filter

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Abstract: ***Rapid sand filtration is a widely adopted technique for purifying water in various applications, ranging from municipal water treatment plants to industrial processes. This abstract provides an overview of the rapid sand filter, highlighting its key principles, advantages, and applications. The rapid sand filter is a gravity-driven filtration system that utilizes a bed of sand as the primary filtration medium. Water flows through the sand bed under gravity or low-pressure conditions, undergoing physical and biological processes that remove suspended solids, pathogens, and other impurities. The sand bed acts as a physical barrier, trapping and retaining particles while allowing the passage of clean water. This abstract discusses the key factors influencing the efficiency of rapid sand filters, including sand grain size, uniformity, and depth. The control of filtration rate, backwashing frequency, and the use of coagulants or flocculants are also addressed, as they significantly impact the filter's performance. Proper maintenance and monitoring are crucial to ensure optimal filter operation and prevent clogging or biofilm formation. Rapid sand filtration offers several advantages, such as simplicity, cost-effectiveness, and ease of operation. It is capable of achieving high removal efficiencies for suspended solids, turbidity, and certain pathogens, making it suitable for a wide range of water treatment applications.***

Keywords: Coarse aggregate, Sand ,Coconut shell.

I. INTRODUCTION

Filtration is a widely used process of removing fine particles from water. The rapid sand filter is an adaptation of a traditional slow sand filter, which has been used for community water treatment for almost 200 years. The rapid sand filter is smaller in size and adopted for intermittent use, making it suitable for garden and agricultural purposes. The filter container can be made of concrete or plastic and is filled with layers of specially selected and prepared sand and gravel. In rapid filtration sand is commonly used as the filter media but the process is quite different from slow sand filtration. The advantage of rapid sand filter is that it is easy to maintain and can be operated for high water demand with less area. Capping is a process of covering the filtration media by appropriates caps such as Anthracite coal, Bituminous coal, crushed coconut shell, PVC Granules etc. In developed countries to overcome the problems of RSF, engineers tried techniques such as rapid sand filter capping with capping materials anthracite coal. Anthracite coal is costly and not easily available in India. So cheaper materials like PVC granules crushed coconut shell are used. So, in this work crushed coconut shells are used to check their suitability.

A. *Advantages of Rapid Sand Filter Using Coconut Shell as Capping Media*

1) *Cost-effective:* Coconut shells are a readily available and inexpensive material, making them a cost-effective choice for capping media in rapid sand filters.
2) *Renewable and Sustainable:* Coconut shells are a natural by product of the coconut industry, and using them as capping media promotes sustainability by utilizing a renewable resource.
3) *Adsorption Properties:* Coconut shells have excellent adsorption properties due to their high carbon content. They can effectively remove impurities, such as organic compounds and certain heavy metals, from the water during filtration.
4) *Longevity:* Coconut shells are durable and have a long lifespan, allowing them to be used as a capping media for an extended period before replacement is required.
5) *Light-weight:* Coconut shells are relatively lightweight compared to some other capping media options. This characteristic makes them easier to handle during installation, maintenance, and replacement.

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B. Disadvantages of Rapid Sand Filter Using Coconut Shell as Capping Media

1) *Limited Application:* The use of coconut shells as capping media may be limited to specificfiltration applications. Theymay not be suitable for filtering water with high turbidity or certain types of contaminants that require alternative filtration methods.
2) *Variable Quality:* The quality of coconut shells can vary depending on factors such as the maturity of the coconuts and the processing method. Inconsistent quality can affect the filtration efficiency and effectiveness of the rapid sand filter.
3) *Clogging Potential:* Coconut shells have a higher potential for clogging compared to conventional sand media. Fine particles or debris from the shells may accumulate over time, leading to decreased flow rates and increased maintenance requirements.
4) *Limited Research and Data:* Although the use of coconut shells as capping media in rapid sand filters has been explored to some extent, there may be limited comprehensive research and data available on their long- term performance and effectiveness. This lack of information could pose challenges for engineers and operators when designing and operating filtration systems.

II. OBJECTIVES

1) To remove the turbidity effectively.
2) To compare performance of dual media filter over Conventional Rapid sand filter.
3) To make use of easily and naturally available material like coconut shell in filtration.
4) To study and suggest various applications of capped dual media filter with coconut shellfor all possible outcomes.
5) To reduce water pollution, improve water quality, reduce the cost of providing clean water and improve ecosystem.
6) Maintain water quality to acceptable levels.

III. LITERATURE SURVEY

1) *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 operationof rapid sand filtration.
2) *Ansari Mubeshshera Awais -2017:* The attempt is made to study the effect of capping of the pilot big sf using coconut as capping media by pilot scale study. The pilot scale study has shown very encouraging results, comparative study shown that effective in improving the performance of RSF in pilot scale. Use of filter with coconut shell as capping media for longer period will give better efficiency. Higher rate filtration is possible along with higher filter run and lessbackwash requirement. The topmost layer of 75 cm and intermediate layer of 10cm and bottom layer of 10cm.
3) *Ast. Prof. Karmaveer Bhaurao Patil – 2014:* In this work, two pilot filter columns are installed, one is conventional rapid sand filters and other is Capped rapid sand filter. Conventional filters have sand as filtration media and gravel as supporting media. In Capped filter, modification is done in the form of capping of PVC granules. Different filter runs are taken by using PVC granules as capping material. Depth of capping media is kept as 3 cm and 5cm. Initial raw water turbidity is kept in 25 NTU. The alum dose is 15 mg/l. Filterruns are taken with two different filtration rates 5.4m/hr. and 7.2 m/hr.

IV. MATERIALS REQUIRED

1) *Gravel:* Gravel which is retained on 4.75mm has been used as supporting media for the sand layer. The depth of the gravel layer in the filtration units is 12cm. The gravel was washed and oven-dried thoroughly before using as the supporting filter media layer.



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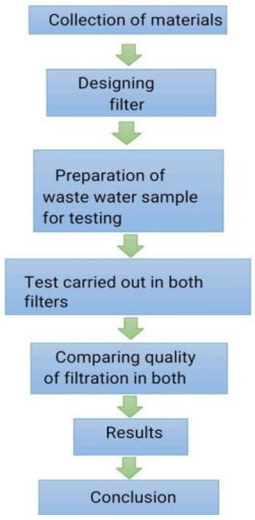
2) *Sand:* River sand having a uniformity coefficient of 1.7 and an effect size of 0.60mm is used as filter material. The sand was washed clean, sun-dried, and oven-dried before using as filter media. The depth of the sand layer maintainedin the filtration unit is 10cm.



3) *Crushed Coconut Shell:* Crushed coconut shells having an effective size of 1.91 mm were used as capping media above the sand layer. Crushed coconut shells were placed in layers above the sand as capping. The depth of the coconut layer infiltration unit was 10 cm. Coconut shells were crushed into pieces manually using a rammer and then thoroughly cleaned before using it as capping. Crushed coconut shells were washed and oven-dried for 24 hrs.



V. METHODOLOGY



The following procedure was adopted for conducting theexperiment:

1) Filter layer consisting of gravel bed of 12cm thickness, sand layer of 10cm thickness and crushed coconut shell layer of 10cm thickness was spread in the filter unit.
2) The water obtained from the lake is stored in a large container for a detention period of about 1 hour. The supernatant water after the sedimentation process was passed through the rapid sand filter.
3) Influent water is fed into the filter with the help ofa dispenser of 20 litres capacity that has been placed well above the filter unit.
4) A head of water above the filter media in the filtration unit of 10cm was maintained throughoutthe test period. The raw water was fed to filtrationunit continuously through the dispenser placed above the filtration unit.
5) Effluent samples are tested for Turbidity, PH, Acidity, Alkalinity, Total solids, BOD.
6) The experiment was carried out 10 litres.

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VI. EXPERIMENTAL WORK DONE

In this project the design and the material needed to complete the Project Model are as follows.

A. *Materials*

1) *Coarse Aggregate:* Coarse aggregate is sieved in 9.5 mm Sieve and 4.75mm sieve then collected retained aggregate on 4.75mm sieve. It is completely washed with clean water then placed in Oven at 300 degree Celsius for 3 hours.
2) *Fine Aggregate:* Natural Sand is taken then sieved through 1.18mm and 600 micron sieve. Two layers are provided. The first layer is provided the sand retained on 600 micron sieve and the second layer is passing through 600 micron was collected then placed in oven at 300 degree Celsius for 3hours.
3) *Coconut Shell:* Coconut shells are taken and husk is removed. The surface of coconut shell is rubbed with Embric paper to get a husk free surface. It is broken into the pieces with the help of Rammer, then remove the dust using sieves. Again coconut shell pieces are washed through the water to remove dust.

B. *Development of Models*

The working model of "The Conventional Rapid Sand Filter" and "Coconut Rapid Sand Filter" is prepared.

C. *Sieve Analysis*

Sieve analysis for stratification in conventional rapid sand filter helps to determine the particle size distribution of course and fine aggregate. . This is done by sieving the aggregates as per IS Sieves . A different sieve as standardized by IS code is used. Aggregates are sieved through them and collected different size particles left over different sieves. A set of IS sieves of sizes 40mm, 20mm, 9.5mm, 4.75mm, 2.36mm, 1.18mm, 600micron, 425micron, 300micron is used for sieve analysis. For our Filter design 1.18mm and 600 micron are used for fine aggregates. For course aggregate sieve sizes used are 9.5mm and 4.75mm. The aggregates retained on sieves are thoroughly washed to remove silt and then allowed to dry in sunlight, later in oven. Sieve analysis helps to achieve proper gradation of particle size in bed layers.

D. *Filter Design*

The Filter designed is the Cylindrical Shaped.The Dimensions are as follows:

1) Height of Filter is 45cm.
2) Diameter of Filter is 25cm.
3) Diameter of Filter is 25cm.
4) Size and Depth of Bed layers.

Size and Thickness of Layers:

Sl no.	Material Used	Size	Thickness
1.	Coarse Aggregate	4.75m m	12
2.	Fine Aggregate	1st layer – 600 passing 2nd layer – 600 retained	10
3.	Coconut Shells	-	10

E. *Layout of Filter*

Different parts of Filter layout are discussed with respect to their Construction, purpose and working as below,

1) *Conventional Rapid Sand Filter:* This RSF contains 2 layers such as Coarse aggregate, Fine aggregate. The bottom of dispenser is filled with coarseaggregate having depth of 12cm.
2) *Coconut Shell Capped Media Filter:* This RSF consist of 3 layers such as Coarse aggregate, Fine aggregate and Coconut shell. The bottom layer is filled with coarse aggregate having depth of 12cm, the middle layer is filled with fine aggregate having depth of 10cm, top mostlayer is filled with coconut shell having a depth of 10cm.

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F. Sample

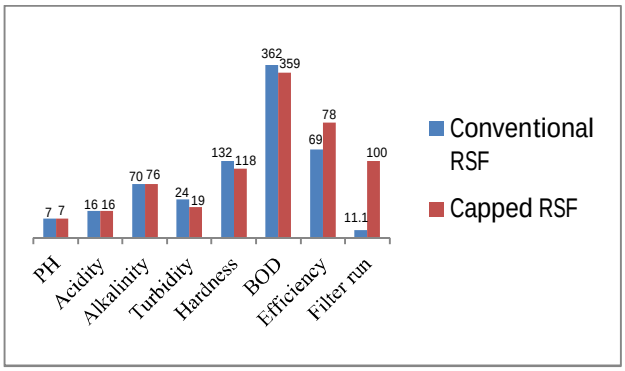
Domestic waste refers to the kitchen waste households from various activities related to cooking, food preparation, and dining etc...Those are produced in the kitchen on a daily basis.

VII. EXPERIMENTAL TEST RESULTAND DICUSSION:

Tests are carried out with three samples accordingly as initial turbid samples, samples of water filtered from conventional rapid sand filter and sample of water filtered from coconut shell capped dual media filter.

Test results are as follows:

Sl. no	PARAMETRS	SAMPLE	CONVENTIONAL RAPID SAND FILTER	CAPPED RAPID SAND FILTER
1.	Colour	Muddy	Colourless	Colourless
2.	PH	6.5	7	7
3.	Acidity	23 mg/l	16 mg/l	16 mg/l
4.	Alkalinity	96 mg/l	70 mg/l	76 mg/l
5.	Turbidity	37 NTU	24 NTU	19 NTU
6.	Hardness	148 mg/l	132 mg/l	118 mg/l
7.	BOD	376 mg/l	362 mg/l	359 mg/l
8.	Efficiency	-	69 %	78 %
9.	Filter run	-	11.1 lit/hr	100 lit/hr



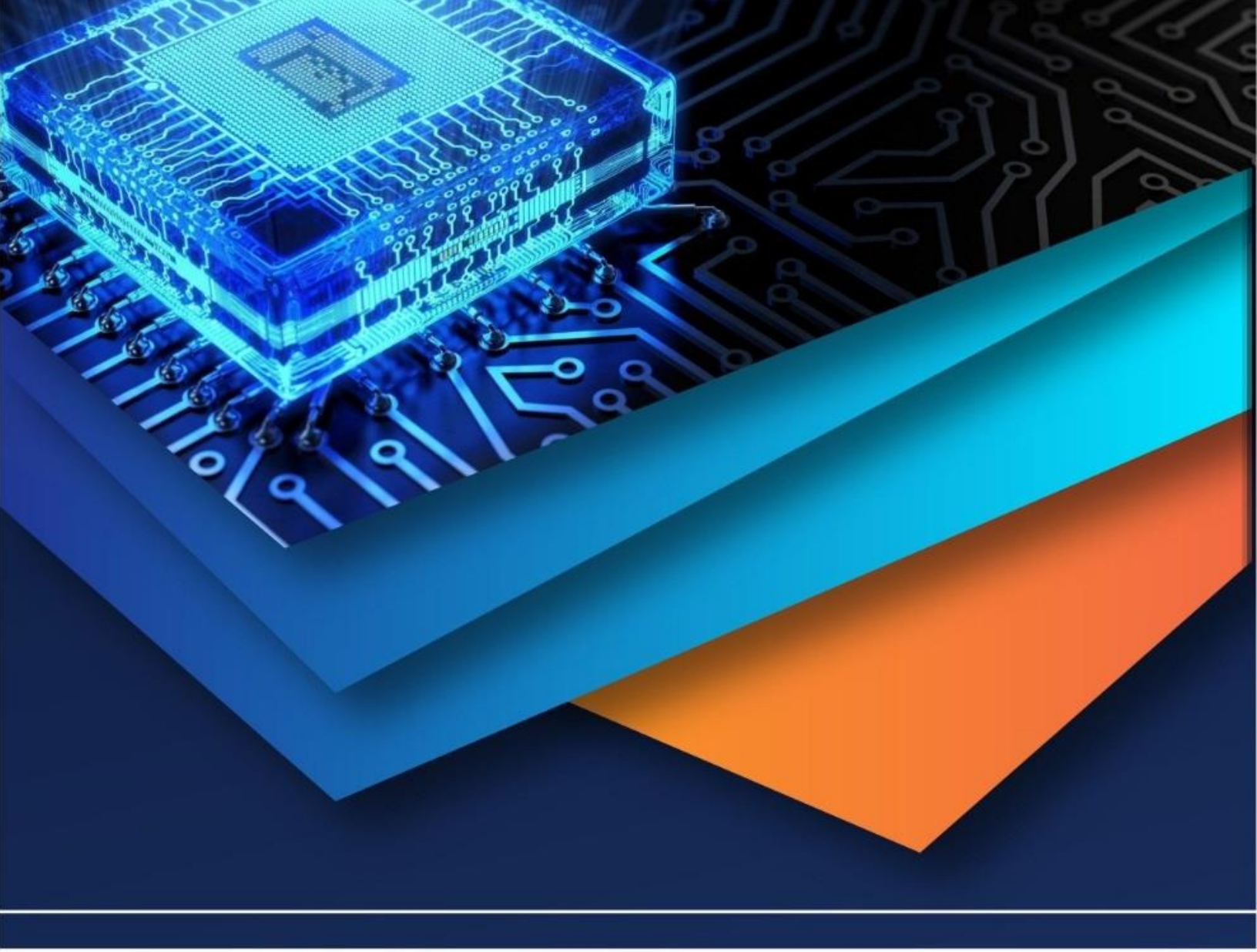
VIII. CONCLUSION

1) In addition to the above layers, by capping the extra layer with crushed coconut shells helps in improving the performance of rapid sand filter.
2) Dual media filter proves to be better alternative for filtration units in treatment plant.
3) It facilitates main purpose of turbidity removal up to 85%, twice filtration rate, reduced head loss, removal of operational troubles like stratification, mud ball formation ,sand leakage.
4) The concern filter model improves quality of filtration with respect to parameters such as
5) It improves Turbidity from 37NTU to 19NTU.
6) It improves efficiency about 78%.

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