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# Rapid Sand Filtration Technique to reduce Iron in SAU Campus

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**ABSTRACT:** The main objective of this research work is to improve the filtration technologies to make them more sustainable and accessible for the public. This study focused on developing improved modified operating methods for rapid sand filtration technology. In this an attempt is made one modified rapid sand filter and compare with conventional rapid sand filter. The main objective to increase the efficiency of conventional rapid sand filters by some modification. For construction of modified filter PVC granules are used as capping material as well as ferric chloride also used. Both the material helps to achieve the lower turbidity and total dissolved solid concentration. In this purpose A Fabricated model was prepared having dimension 17x17x12 m. Gravel, Coconut shell (Activated carbon), Sand was filled in the model in the layer of size 45cm, 40cm, 30cm respectively. The tests which are conducted on sample are pH, Turbidity, BOD, Total solids. It improves the performance of filter in terms of high filtration rate, high turbidity removal and high decrease in percentage of total solids and thus making it more applicable. The results indicate that with the developed rapid-sand filters store rate of 137 gallons per day (g/d), the modified filters would require less cleaning than the other traditional filter. This report proposes the implementation of highly iron mitigation measures to prevent long term health effects. It also contains leaflets for widespread information on the construction, use and maintenance of the SAU authority, decision makers, water specialists and scientists confronted with iron mitigation needs.

**KEYWORDS:** Sustainable, Construction, Rapid Sand Filter, Modified, Technologies.

## 1 INTRODUCTION

Iron is the second most abundant metal in the earth's crust, of which it accounts for about 5%. Elemental iron is rarely found in nature, as the iron ions $Fe2+$ and $Fe3+$ readily combine with oxygen- and sulfur-containing compounds to form oxides, hydroxides, carbonates, and sulfides. Iron is most commonly found in nature in the form of its oxides [1][2]. In drinking-water supplies, iron(II) salts are unstable and are precipitated as insoluble iron(III) hydroxide, which settles out as a rust-coloured silt. Anaerobic groundwaters may contain iron(II) at concentrations of up to several milligrams per litre without discoloration or turbidity in the water when directly pumped from a well, although turbidity and colour may develop in piped systems at iron levels above 0.05–0.1 mg/litre. Staining of laundry and plumbing may occur at concentrations above 0.3 mg/litre [3].

Filtration is a fundamental unit process that is commonly used to help remove particles present in surface water, precipitated hardness from lime-softened water, microorganisms (bacteria, viruses, and protozoan cysts), precipitates of aluminum and iron used in coagulation, and precipitated iron and manganese present in many well water supplies [4][5]. Filtration can be compared to a sieve or micro-strainer that traps suspended material between the grains of filter media. However, since most suspended particles can easily pass through the spaces between grains of the filter media, straining is the least important process in filtration. Filtration primarily depends on a combination of complex physical and chemical mechanisms, the most important being adsorption. Adsorption is the process of particles sticking onto the surface of the individual filter grains or onto the previously deposited materials. Forces that attract and hold particles to the grains are the same as those that work in coagulation and flocculation. In fact, coagulation and flocculation may occur in the filter bed, especially if coagulation and flocculation before filtration was not properly controlled. Incomplete coagulation can cause serious problems in filter operation. Filters may be broadly classified as “rapid” or “slow” based on the rate at which they operate. A slow sand filter is a filter operated at very low filtration rates (usually 0.1~0.2 m/hr) without coagulation in pre-treatment [6].

Capping is the process of covering the filtration media by appropriate caps such anthracite coal, bituminous coal, crushed coconut shell. Capping involves the replacement of portion of sand with appropriate caps. The Proposed study was made to assess the use of Coconut shell as a capping media. Coconut shells are easily available and it helps to tackle some additional flock loads. It improves quality of filtration with respect to bacterial measure.


***Fig. 1. Campus of Sylhet agricultural University***

*Source: (M. A. Hossain et.al.; Sustainable Storm Water Drainage System Design for Sylhet Agricultural University, 2016)*

The primary focus of this research is to design and construct a modified filtration system water treatment. The materials used for the design of modified filtration system; gravel, sand, and PVC granules.

1. To Design and construct pilot scale model of rapid sand filter.
2. To study the performance of rapid sand filter based on the quality of effluent produced.

## 2 MATERIALS AND METHODS

In this chapter, testing facility, experimental procedures and experimental programs are included. Design of experimental set up is done based on the basic design of rapid sand filtration. As per the literature review the design for set-up is done.

### 2.1 MATERIALS

#### 2.1.1 GRAVEL

Gravel which retained on 45cm has been used as supporting media for sand layer. The depth of gravel layer in the filtration units is 20cm. Gravel was washed and oven dried thoroughly before using as the supporting filter media layer.

*Fig. 2. Standard size of Gravel*

#### 2.1.2 SAND

River sand having uniformity co-efficient 1.7 and effective size 0.60mm is used as filter material. Sand was washed with clean and sun dried before using as filter media. The depth of sand layer maintained in the filtration unit is 30 cm.

*Fig. 3. Standard size of Coarse Sand*

#### 2.1.3 ACTIVATED CARBON/ 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 shell was placed in layers above the sand as capping. The depth of coconut layer in filtration unit was 45 cm. Coconut shells were crushed into pieces manually using a rammer then thoroughly cleaned before using it as capping. Crushed coconut shells were washed and oven dried for 24 hrs.

***Fig. 4. Standard size of Coal (Activated Carbon)***

## 2.2 Study Area

Fabricated model was prepared having dimension 17x17x12 m. Gravel, Coconut shell (Activated carbon), Sand was filled in the model in the layer of size 45cm, 40cm, 30cm respectively. The tests which are conducted on sample are pH, Turbidity, BOD, Total solids. It improves the performance of filter in terms of high filtration rate, high turbidity removal and high decrease in percentage of total solids and thus making it more applicable.

The Filter was installed in Abus Samad Azad Hall. The Sample was collected from the dining place and different floor in this hall. The sample collected was turbid. The sample was collected in cans. The water was tested Agricultural Construction and Environmental Engineering lab for sieve analysis and water quality testing. Water sample was bought to laboratory and it was kept in large containers for sedimentation process with detention period for 3-4 hrs. The supernatant water was collected and then passed through Rapid Sand Filter.

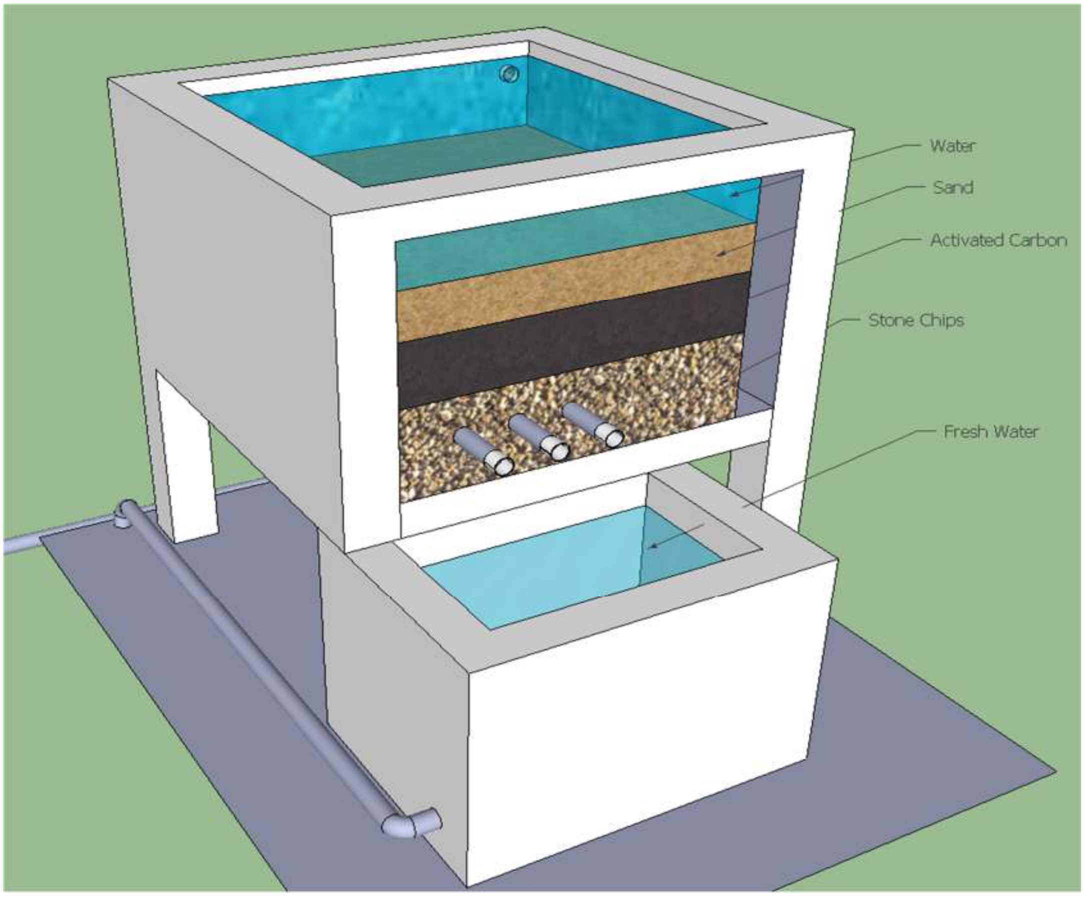


*Fig. 5. Proposed a Fabricated model*

### 2.3 EXPERIMENTATIONS

Various experiments were performed for water i.e., pH, Turbidity and Total dissolved solids to determine the initial and final concentration. pH of the sample helps to determine the acidic or basic characteristics. Generally, the pH scale varies from 0 to 14. 0 to 7 is acidic, 7 are neutral and 7-14 is alkali in nature. According to drinking point of view it plays an important role. Continuous use of acidic or alkali water create the serious health issues.

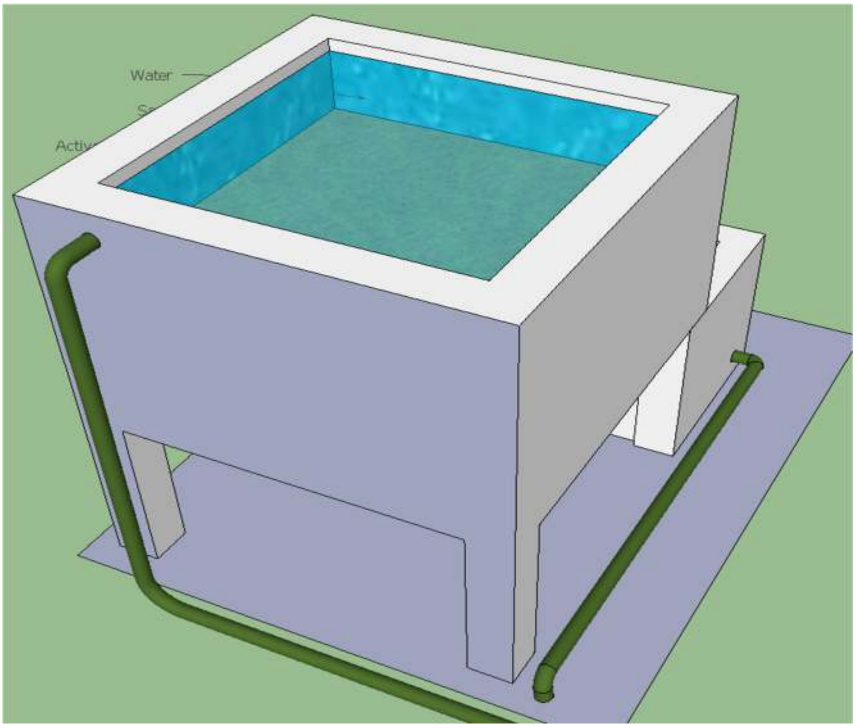


*Fig. 6. Angle View of Modified Rapid Sand Filter*

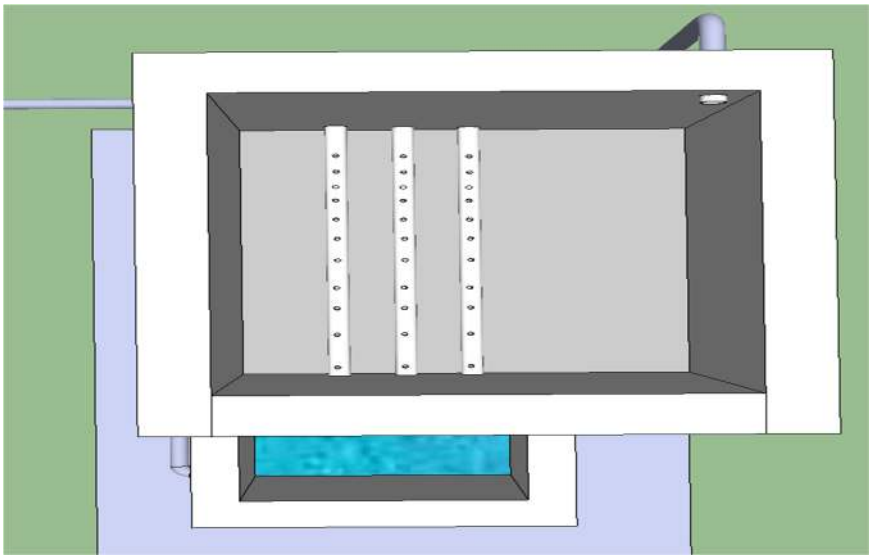

*Fig. 7. Top View of Modified Rapid Sand Filter*

Aggregate gradation (sieve analysis) is the distribution of particle sizes expressed as a percent of the total dry weight. Gradation is determined by passing the material through a series of sieves stacked with progressively smaller openings from top to bottom and weighing the material retained on each sieve. For the characterization of bulk goods of different forms and sizes, the knowledge of their particle size distributions is essential. The particle size distribution, i.e. the number of particles of different sizes, is responsible for important physical and chemical properties such as solubility, flowability and surface reaction. Gradations are expressed on the basis of total percent dry weight passing, which indicates the total percent of aggregate by weight that will pass a given size sieve.

Some of the descriptive terms used in referring to aggregate gradations are:

Coarse Aggregate: All the materials retained on and above the No. 8 (2.36 mm) sieve
Fine Aggregate: All the material passing the No. 8 (2.36 mm) sieve.

### 2.4 Fineness Modulus

Fineness Modulus is defined as an index to the particle size not to the gradation. Fineness Modulus is calculated from the sieve analysis. It is defined mathematically as the sum of the cumulative percentages retained on the standard sieves divided by 100. The standard size sieves are 6" (150 mm), 3" (75 mm), 1 ½" (37.5 mm), ¾" (19.0 mm), 3/8" (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300µm), and No. 100 (150 µm). Always report the fineness modulus to the nearest 0.01. In fineness modulus, the finer the material the more the water demand is. It is used for the purpose of estimating the quantity of coarse aggregate to be used in the concrete mix design. The F.M. of fine aggregates should not be less than 2.3 or more than 3.1, or vary by more than 0.20 from batch to batch.

### 2.5 Apparatus

1) Balance or scale: Capacity sufficient for the sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g
2) Sieves
3) Mechanical sieve shaker
4) Suitable drying equipment
5) Containers and utensils: A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water

### 2.6 Sample Sieving

In this procedure it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification.

Sieves are nested in order of decreasing size from the top to the bottom and the sample, or a portion of the sample, is placed on the top sieve.

Sieves are shaken in a mechanical shaker for approximately 10 minutes, or the minimum time determined to provide complete separation for the sieve shaker being used. As established by the Time Evaluation.

### 2.7 Time Evaluation

The minimum time requirement should be evaluated for each shaker at least annually by the following method:

1. Shake the sample over nested sieves for approximately 10 minutes.

2. Provide a snug-fitting pan and cover for each sieve, and hold in a slightly inclined position in one hand.

3. Hand-shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

If more than 0.5 percent by mass of the total sample prior to sieving passes any sieve after one minute of continuous hand sieving adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

## 3 RESULTS AND DISCUSSION

*Table 1. Particle Size Distribution for gravel/Stone*

| Sieve Size (mm) | Weight retained | Cumulative weight retained | Cumulative percentage of weight retained |
|---|---|---|---|
| 50 | 0 | 0 | 0 |
| 37.5 | 0 | 0 | 0 |
| 25 | 170 | 170 | 8.67 |
| 19 | 460 | 630 | 32.14 |
| 12.5 | 830 | 1460 | 74.49 |
| 9.5 | 300 | 1760 | 89.79 |
| 6.3 | 200 | 1960 | 100 |
| Pan | 40 | 2000 | |
| | 2000 | | Total= 305.09 |

*Sample of sand = 500 gm*
*Fineness Modulus (F.M.) = (cumulative) % / 100 = 2.94*

*Table 2. Particle Size Distribution for Sand*

| Mesh no | Sieve size (mm) | Sieve weight without sand (gm) | Weight retained (gm) | Cumulative weight retained (gm) | Cumulative percentage weight retained (%) |
|---|---|---|---|---|---|
| **4** | 4.67 | 309.91 | 0 | 0 | 0 |
| **8** | 2.38 | 321.03 | 0.13 | 0.13 | 0.026 |
| **16** | 1.19 | 322.66 | 40.32 | 40.45 | 8.09 |
| **30** | 0.595 | 303.92 | 78.58 | 119.03 | 23.806 |
| **50** | 0.297 | 293.64 | 232.46 | 351.49 | 70.298 |
| **100** | 0.149 | 292.36 | 112.32 | 463.81 | 92.762 |
| **200** | 0.074 | 280.44 | 31.51 | 495.32 | 100 |
| **pan** | | 283.00 | 4.37 | 500 | |
| | | | 500 | | 294.98 |

*Sample of sand = 500 gm*
*Fineness modulus = (cumulative) % / 100*
*= 2.94*

### 3.1 CALCULATIONS

1. The sum of the individual weights retained on each sieve and in the pan shall not vary be more than 1% from the original weight of the sample. When the loss or gain is greater than 1%, the test shall be considered invalid and another portion shall be tested. If the sum of the individual weights is within the 1% limit, the difference between the sum of the individual weights and the original weight shall be added to or subtracted from the sieve with the largest amount of material retained.
2. Fine Aggregate (% Retained): The percent retained on each sieve is computed by dividing the weight of the material retained on that sieve by the original weight (determined in 1004.03-1) of the sample before washing and multiplying by 100 and reported to the nearest 0.01%. This value shall be truncated at 0.01% and shall not be rounded.
3. Coarse Aggregate (% Retained): The percent retained on each sieve is computed by dividing the weight of the material retained on that sieve by the original weight (determined in 1004.03-1) of the sample and multiplying by 100 and reporting to the nearest 0.01%. This value shall be truncated at 0.01% and shall not be rounded. The material for determination of the percentage finer than the 75 µm (No. 200) sieve shall be obtained from a separate representative sample that has been placed in a proper plastic container. This percentage shall be determined in accordance with the above procedure.
4. Fine and Coarse Aggregate (% Passing): The percent passing a given sieve is computed by subtracting the percent retained on that sieve from the total percent passing the next larger sieve in the sieve series used and calculated to the nearest 0.01%.

## 4 CONCLUSION

1. Coal as like Coconut shell (Activated Carbon) when used as a filter media in the filtration process gives good efficiency.
2. There was considerable reduction in turbidity, total solid, pH and BOD.
3. There was considerable reduction in the color intensity.
5. The reduction in turbidity is up to 90%.
6. The Decrease in the total solids was upto 89%.
7. Reduction of BOD proves that organic compound can be efficiently removed by Coconut shell.

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