

## Modeling and designing of rapid sand filter

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### ABSTRACT

*Day by day the quality of drinking water is deteriorating. Hence it is a need of the time to supply clean and safe drinking water to the public. Sand filtration is one of the techniques used for to obtain the clean water. According to the World Health Organization, water and sanitation are the primary drivers of public health. 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 overall 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 help to achieve the lower turbidity and total dissolved solid concentration.*

**Keywords:** Sustainable, Construction, Rapid Sand Filter, Modified, Technologies

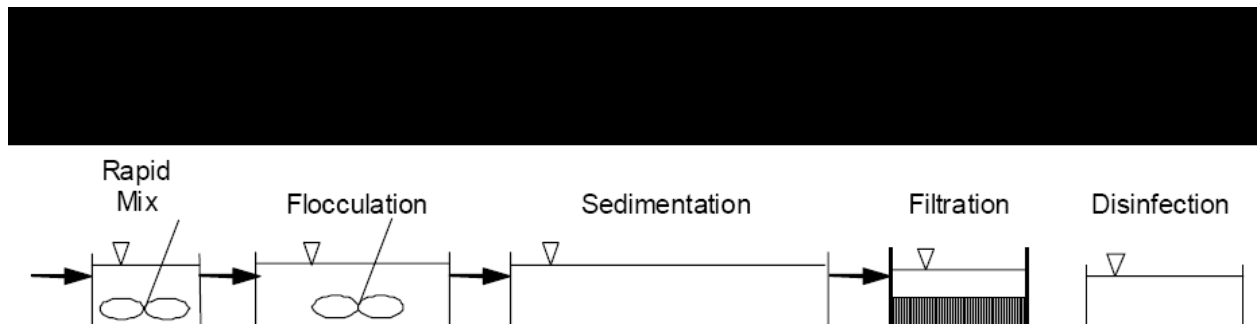
### 1. INTRODUCTION

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. 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. Rapid sand filtration was introduced in the United States in the 1880s and has been widely accepted for municipal application because of its high productivity and flexibility in treating waters of different turbidities (Tate 1980). In drinking water treatment, the function of rapid sand filters is to remove particulate matter in the influent suspension and provide significant pathogen removal. In contrast to slow sand filters, rapid sand filters are operated at a much higher filtration rates (5~10 m/hr) and are frequently

used in water treatment following pre-treatment of the raw water by chemical coagulation, flocculation, and sedimentation

### Water Treatment Units and Process:

The units and processes of Water Treatment Plant.



- **Coagulation:** Aluminum or iron salts and chemicals are rapidly mixed with the turbid water so that the particles in the water stick together.
- **Flocculation:** The coagulated particles are slowly mixed so that they can collide and form larger particles known as floc.
- **Sedimentation:** Water flows through a large tank which allows the floc to settle down to the bottom of the tank then removed as sludge.
- **Filtration:** Water is passed through filters made up of sand and anthracite coal to filter out remaining particles.
- **Disinfection:** Chlorine is added to water which kills bacteria and other disease-causing organisms. This process ensures the good water quality throughout the distribution pipe system.
- **Rapid Sand Filter:** The water treatment plant has filtration unit which plays important role in purification process of raw water which is named as Rapid Sand Filter (RSF). In India, due to high filtration rate, the most of the water treatment plants prefer to Rapid Sand Filter (RSF). The RSF removes the flocs. The filter media gets clogged due to flocs deposition. Hence the backwashing is required to remove these deposited flocs. After back washing the ripening of the filter begins. During the ripening process there is a sudden increase in turbidity due to presence of remnants in a sand media and above the sand media

## II. MATERIAL AND FABRICATION OF MODEL

Two models were fabricated for experimental point of view. One is conventional sand filter and other is modified sand filter. For conventional sand filter the materials base material is gravel and filter material is sand. For modified filter along with gravel and sand, ferric chloride and PVC granules also used.

**Gravels**

- ~ Used as supporting material for filter.
- ~ 4-5 layers of gravel, larger at bottom and smaller at top.
- ~ Gravels sieved at 13.2 mm, 9.5 mm and 8 mm.

**Sand**

- ~ Used as filter material.
- ~ 2 layers of sand filter for filtration activity.
- ~ Sand collected and sieved by 710 micron sieve.
- ~ Properly cleaned and oven dried at 105 ° C.

**PVC Granule**

- ~ Used as capping material.
- ~ Collected from local vendor of size 2-4mm.
- ~ Washed properly and oven dried at 50° C.
- ~ 2 layers in between the filter material.

**Admixture**

- ~ 0.15 mg of Ferric chloride added to 1L of raw water.
- ~ It acts as a disinfectant as well as coagulant.
- ~ Increase the efficiency of overall modified filter.

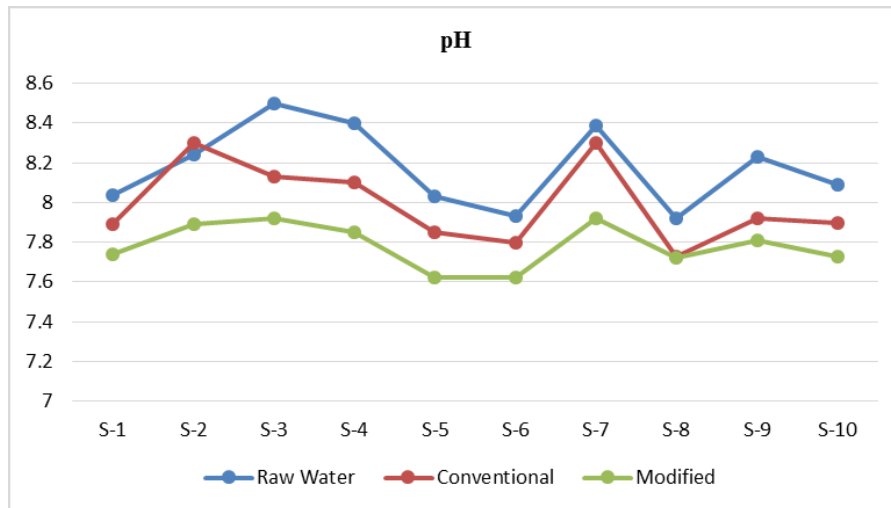


1. Slow sand filter 2. Rapid sand filter

**III.FIGURES AND TABLES**

The result of pH didn't have much more effect on both type of filter.

the raw water, conventional and modified filter the pH is around 7.6 to 8.3. According to drinking point of view the pH is around 6.5 to 7.5.



**Fig. pH analysis result**

Filtration efficiency mainly depends on porosity of media used for filtration work. PVC granule capping depth – 5.5cm (2.5 and 3 cm), compared to sand and so larger particles remains on top after backwashing it also provides larger depth for filtration and improves performance by removing larger suspended particles at initial stage. Due to porous nature maximum throughput volume can be achieved and also run length is increased. This is the reason due to which modified sand filter has a better efficiency in terms of removal of turbidity with compare to conventional filter. In conventional filter turbidity is increased due to the filter media. When the raw water is passed through the sand particles, the water gains some turbidity. Ferric chloride also used as a admixture to modified filter. This also helps to achieve the efficiency of removal.

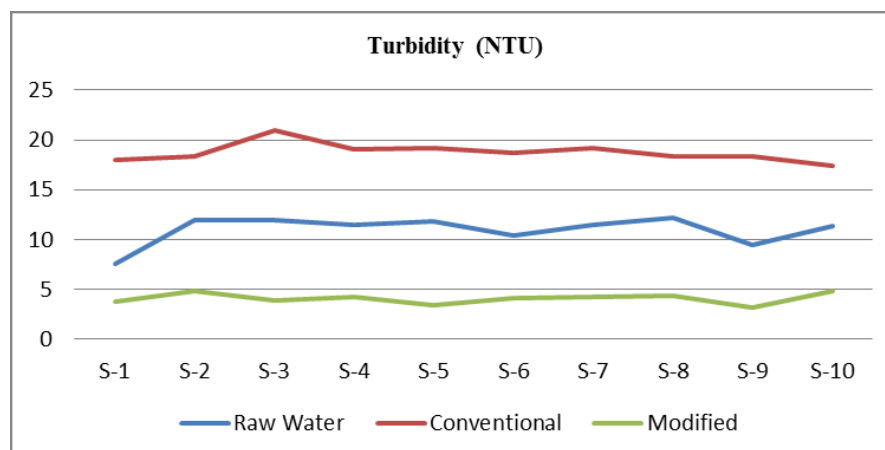


Fig. Turbidity result analysis

In respect to total dissolved solids removal modified sand filter is able to remove the dissolved solids with compare to conventional filter. The better removal efficiency in modified sand filter is achieved due to two layers of sand with proper capping with PVC granules.

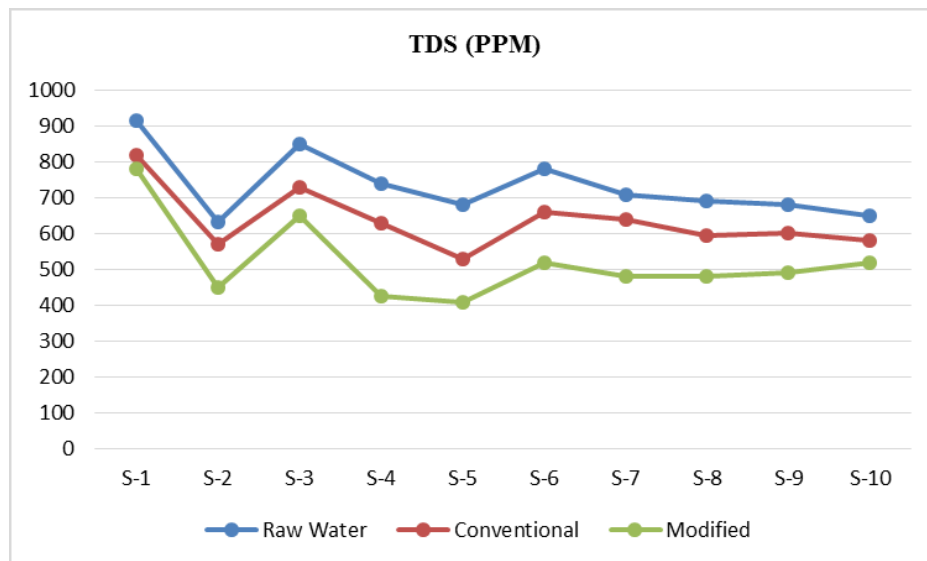


Fig. 5: Total dissolved solids result analysis

#### IV.CONCLUSION

The conclusion can be drawn from this research work is:

~ Instead of providing one sand layer of for filtration work, sand layer with two capping is also useful to carry out efficient filtration work.(BIBHABASU MOHANTY,MAY 2017,DESDIGN AND CONSTRUCTIONOF MODIFIED RAPID SAND FILTER)

~ Capping with PVC granules with 2.5 cm and 3 cm capping layer increases turbidity removal efficiency. (BIBHABASU MOHANTY,MAY 2017,DESDIGN AND CONSTRUCTION OF MODIFIED RAPID SAND FILTER)

~ Capping proves an efficient technique for improving performance of rapid sand filters in terms of head loss development, filter run length and turbidity removal efficiency.(RANJEET SABALE,OCTOBER 2014,IMPROVED RAPID SAND FILTER FOR PERFORMANCE ENHANCEMENT)

~ Capping with PVC granules with 3cm depth gives turbidity removal up to 92% while Capping with 5cm depth gives turbidity removal up to 96%(RANJEET SABALE,OCTOBER 2014,IMPROVED RAPID SAND FILTER FOR PERFORMANCE ENHANCEMENT)

~ Combination of both ways during ripening and backwash will be employed to determine the optimum dose of coagulants.(C.H.Wagh, 28-30 April, 2016,IMPROVING THE INITIAL FILTRATE QUALITY OF RAPID SAND FILTER BY OPTIMIZING COAGULANT DOSE DURING BACKWASHING AND RIPENING OPERATION FOR WATER TREATMENT PLANT-A REVIEW)

~ The optimum dose and its way of adding are to be considered for preserving desired initial filtrate quality.(C.H.Wagh, 28-30 April, 2016,IMPROVING THE INITIAL FILTRATE QUALITY OF RAPID SAND FILTER BY OPTIMIZING COAGULANT DOSE DURING BACKWASHING AND RIPENING OPERATION FOR WATER TREATMENT PLANT-A REVIEW)

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