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Improved Rapid Sand Filter for Performance Enhancement

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Abstract: ***Filtration is process in which water is purified by passing through sand media. In India rapid sand filters are used conventionally for filtration. Sand media having characteristics as effective size (E.S. – 0.35-0.60mm), uniformity coefficient (U.C. - 1.3-1.7), specific gravity- 2.67, limiting head loss- 1.8-3.0m, depth of sand- 60cm, depth of gravel support-40 cm, etc. The advantages of rapid sand filter are easy operation, less space requirement, more filtration rate, more output and easy backwashing. Along with some advantages there are some drawbacks in rapid sand filter. Due to improper backwashing mud ball formation is a major problem shown in filter media. At the time of backwashing process stratification of sand media takes place. Sand grains having small size come at top layer. It reduces porosity at top layer which results in maximum removal at top layer. Therefore head loss increases in shorter run time which affects filtration process. To overcome these problems researchers have tried for capping of rapid sand filter. Capping is process in which upper sand bed layer of few cm is replaced with capping material. Some materials suitable for capping are anthracite coal, PVC granules, Polypropylene bids, and bituminous coal etc. In the present work conventional rapid sand filter and capped rapid sand filter are compared.***

Keywords: Rapid sand filtration, capping of filters, PVC granules

1. Introduction

Granular filtration is the process whereby water is purified by passing it through a porous material. In rapid filtration sand is commonly used as the filter medium but the process is quite different from slow sand filtration. This is so because much coarser sand is used with an effective grain size in the range 0.35-0.60 mm, and the filtration rate is between 5 and15 m/h. Due to the coarser sand used, the pores of the filter bed are relatively large and the impurities contained in the raw water penetrate deep into the filter bed. Thus, the capacity of the filter bed to store deposited impurities is much more effectively utilized and even very turbid river water can be treated with rapid filtration. Cleaning of rapid filters is done by backwashing. This involves air wash followed by water wash for certain time.. Rapid sand filters are filters of conventional type, used widely in treatment plants all over the world. In India most of the water treatment plants use rapid sand filter for water treatment. The advantage of rapid sand filter is that it is easy to maintain and can be operated for high water demand with less area. Along with some advantages there are some drawbacks in rapid sand filter. Stratification of sand layers at time of backwash, mud ball formation, rapid increase in headloss, less throughput volume, low effluent quality these problems are related to rapid sand filters. In developed countries to overcome such problem engineers tried techniques such as rapid sand filter capping with capping materials as anthracite coal. Anthracite coal is costly and not easily available in India. So cheaper materials like PVC granules, crushed coconut shell, bitumen coal, fiber mat and synthetic nylon fibers are tried.This paper focuses on a cheaper and easily available capping material for better operation of rapid sand filtration. So in these work PVC granules are used to check its suitability.

2. Methodology

2.1 Methodology adopted for filtration work

In this work, two pilot filter columns are installed one is conventional rapid sand filters and other is Capped rapid sand filter. Conventional filter has 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. Alum dose is 15 mg/l. Filter runs are taken with two different filtration rates 5.4m/hr and 7.2 m/hr.

2.2 Material for capping

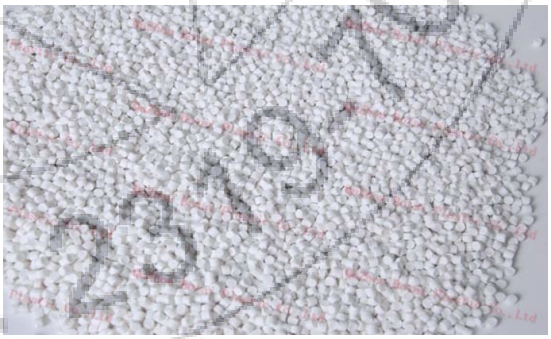


Figure 1: PVC Granules
Sizerange – 2 to 4mm
Specific gravity- 1.2

Filtration work is carried out by using capping of PVC granules. Capping is done with two different depth namely 3cm and 5cm.for three different filtration rates run is taken and head loss and turbidity removal variation is measured.

3. Experimental Study

3.1 Experimental Set up

Design of experimental set up is as per basic design of rapid sand filtration. As per the literature review the design for set-up is done. For set-up two filter column required. One is of regular rapid sand filter and another is modified rapid sand filter. Filter column of acrylic material having 10 cm diameter and 2 meter in length was selected. For filter column the depth of sand media and depth of base material is provided as used in conventional rapid sand filter i.e. 60 cm sand bed and 40 cm respectively. For modified filter sand depth is selected based on defined configuration. The head loss port and sampling port are drilled exactly opposite for easy working. The port is drilled at 15 cm distance apart from each other. There is provision to collect sample at different time and depth. For collection of sample five sample ports are provided. Also there is arrangement is made to measure head loss at different time and depth. For that purpose head loss measuring tube that is level tube is connected to filter column. Head loss measuring tubes has height of approximately 3 m.

Filter columns are installed with the help of stand on flat surface and the plumbing connections are made by APVC pipes as shown in figure. The two overhead tanks of 30 liters are provided, one is having turbid sample and another is clear water for backwashing. The 50 liters of a tank is placed near set-up in which turbid sample is to be made which is pumped in overhead tank with the help of 0.5 HP pump. The overflow outlet is provided to maintain constant head. The filter column top is closed by removable acrylic cap having two holes for one inlet and another for vent pipe.

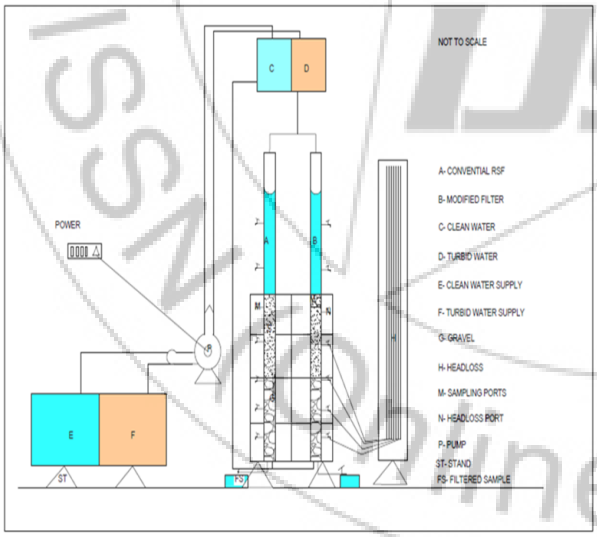


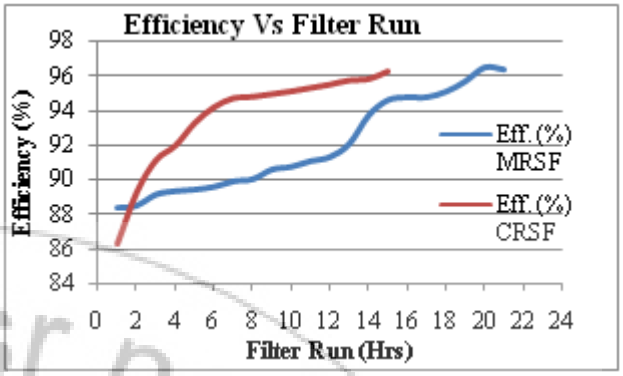
Figure 2: Experimental set up

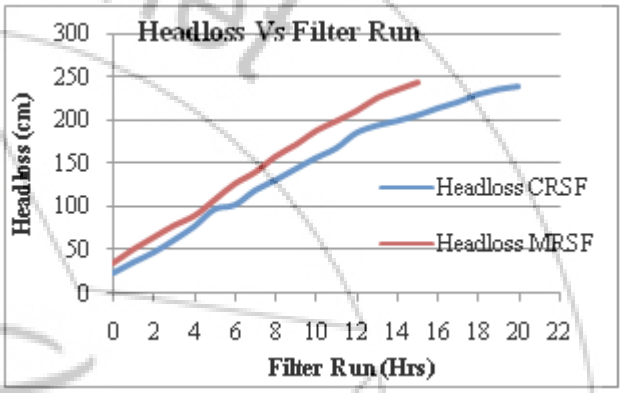
3.2 Comparison of Performance of conventional and modified rapid sand filters.

Comparative study of filters is done for different parameters like turbidity removal, head loss development, filter run length. Following graph shows performance of both filters under same working conditions.

Run1.Filtration rate- 5.4m/hr

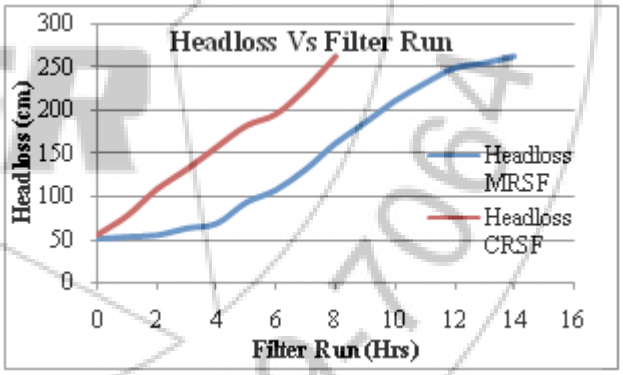
PVC granule capping depth -3cm

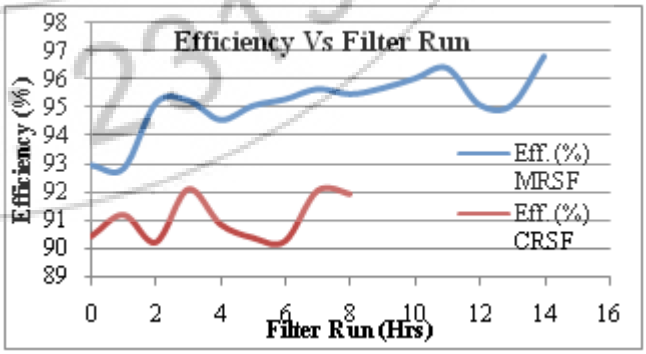




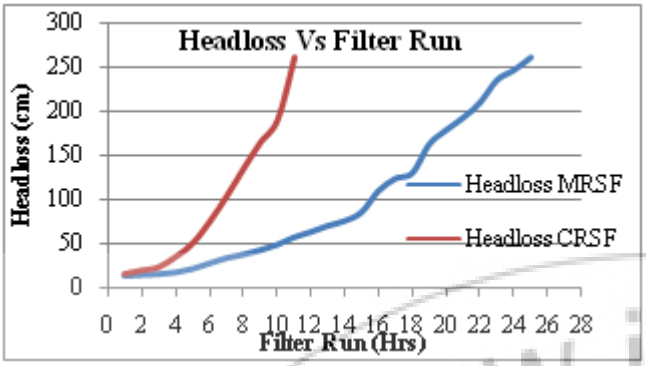
Run2. Flow rate- 7.2m/hr

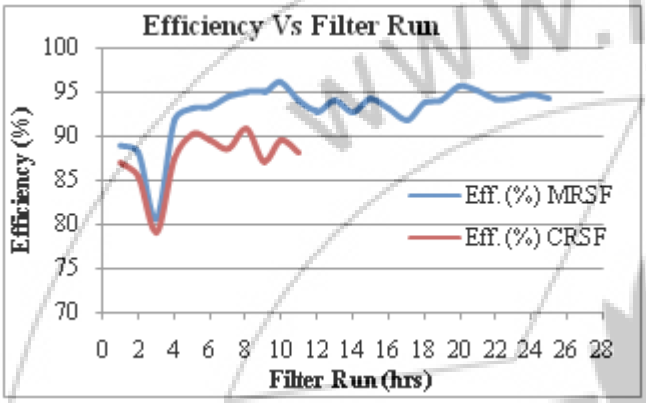
PVC granule capping depth - 3cm.



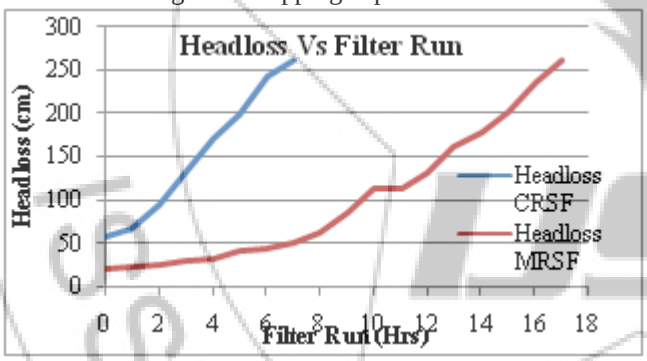


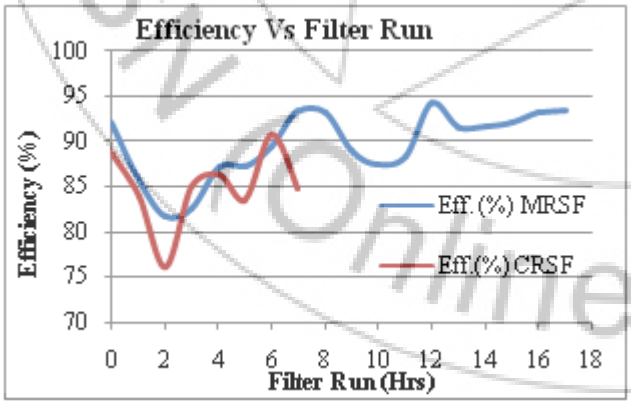
Run 3. Flow rate- 5.4m/hr.
PVC granule capping depth - 5cm,





Run4. Flow rate-7.2m/hr
PVC granule capping depth - 5cm.





4. Result and Discussions

From graphs obtained from performance of pilot filter columns, it is observed that as filtration rate affects length of filter run resulting in shorter filter run length. Filtration efficiency mainly depends on porosity of media used for filtration work. PVC granules have less specific gravity 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.

Filtration efficiency of capped filter is about 95% while that of conventional filter is about 89%. Run length of capped filter is about 2 to 2.5 times more than that of conventional filter. Backwashing is done more effectively in capped filter than conventional filter. So reduction in back wash water requirement is observed up to 35%.

5. Conclusions

1) 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.
2) Capping with PVC granules with 3cm depth gives turbidity removal up to 92% while Capping with 5cm depth gives turbidity removal up to 96%.
3) Filter run length of capped rapid sand filter increases up to 2 to 2.5 times than that of conventional rapid sand filter.
4) Backwash water requirement for capped rapid sand filter is about 40% that of conventional rapid sand filter i.e. back wash water requirement is reduced by 60%.

6. Future Scope

1) TO find alternate capping media to PVC granules.
2) To perform chemical analysis of PVC granules.
3) Detail backwash study for capped rapid sand filter.

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