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Improvement of Performance of Rapid Sand Filter using Coconut Shell as Capping Media

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Abstract: ***Rapid sand filters are very common in all conventional water treatment plants. The major problem associated with it is stratification, which restrict the complete utilization of sand bed used. Also most of the rapid sand filter beds are suffering by the problems like mud ball formation, unsatisfactory effluent and high backwash water requirement. Dual media and multimedia filters can overcome the limitations of rapid sand filters. Alternatively, higher filtration rates even can be achieved. However, the use of such techniques is limited in India due to unavailability of filter materials apart from sand. Capping of existing rapid sand filters can be the promising method of improving the performance of rapid sand filters. Capping is a process of covering the filtration media by appropriates caps such as Anthracite coal, Bituminous coal, Crushed coconut shells, etc. The attempt is made to study the effect of capping of RSF by the use of coconut shell as a capping media by pilot scale study. The pilot scale study has shown very encouraging results. Comparative study shown that higher rate of filtration is possible along with higher filter run and less backwash requirement.***

Keywords: Rapid sand filters, stratification, Capping of rapid sand filters, coconut shell, filter run, backwash requirement

1. Introduction

Filtration is a process that is widely used for removing fine particles from water remains after the process of clarification. Almost all conventional surface water treatment facilities and some groundwater treatment facilities make use of rapid sand filters (RSF). The depth of filter bed is generally 60cm to 75cm thick with sand of effective size 0.45 to 0.70 mm and uniformity coefficient of 1.3 to 1.75.

The major drawback of RSF is stratification of filter bed after backwashing as fine particles takes more time to settle as compared to coarser particles (Stoke's Law). Large numbers of existing RSFs are facing the problems like, bad overall performance and unsatisfactory water supply besides unsatisfactory operation and maintenance. Most of the rapid sand filter beds are suffering by the troubles like mud ball formation, unsatisfactory effluent and higher backwash water requirement. Also most of the conventional water treatment plants are overloaded due to increased demand which highlights the need of higher filtration rate. Dual media and multimedia filters can overcome these limitations of rapid sand filters. Alternatively, higher filtration rates even can be achieved. However, the use of such techniques is limited in India due to unavailability of filter materials apart from sand. Capping of existing rapid sand filters is the promising method of improving the performance of rapid sand filters. Capping is a process of covering the filtration media by appropriates caps such as Anthracite coal, Bituminous coal, Crushed coconut shells, etc. Capping involves the replacement of a portion of the sand with appropriate caps. Such an improved filter, though inferior to the originally designed dual media filter, is better than the conventional RSF from the point of view of the rate of filtration as well as total filter run. The proposed study was made to assess the use of coconut shell as a capping media.

2. Objectives of Study

The objectives of the study were,

2.1 Designing and constructing pilot scale model of rapid sand filter and capped rapid sand filter using crushed coconut shell as capping materials.

2.2 To compare the performance of conventional rapid sand filter and capped rapid sand filter on the basis of total length of filter run, quality of effluent produced and back wash requirement.

3. Methodology

To fulfill the objectives following methodology was adopted.

3.1 A pilot scale model of filter was constructed using glass columns with an inside area of 0.15m X 0.15m along with associated piping and valves. The pilot model was installed at Ichalkaranji water treatment plant, where the clarified water was used for the performance evaluation of capped RSF and comparison of its performance was made with the conventional RSF performance.

3.2 The sand media of desired effective size and uniformity coefficient was prepared by sieving the washed and sun dried stock sand. The coefficient of uniformity of sand used was 1.7 and effective size was 0.6mm.

3.3 The crushed coconut shell was used as capping materials. The size was determined by considering the fact that the settling velocity of the finest sand particle to be more than the settling of capped media particles. The depth of capping was kept as 10cm. Coconut shells of required size and uniformity are obtained by crushing and sieving it. The crushed coconut shell was charged by heating before use. The coefficient of uniformity of capping media used was about 1 and effective size was 1.91 mm.

3.4 The filter runs were conducted for about 3 days. During this, samples of influent and effluent are collected from for the conventional pilot scale filter (RSF) and capped pilot scale filter and the turbidity of these were checked.

Along with this comparison was also done for the length of filter run, time of backwash and ripening period.

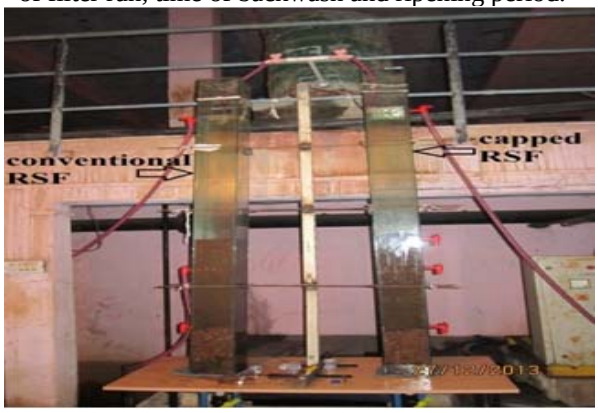

Figure 1: Photograph of installed pilot plant at Ichalkaranji WTP

Figure 2: Photograph of capped sand media

4. Results and Discussion

The results obtained during the sampling were as follows:

Table 1: Turbidity removal in first filter run at filtration rate of 5m/hr

Time in hr.	Turbidity of influent in NTU	Turbidity of effluent of conventional R.S.F. in NTU	Turbidity of effluent of capped R.S.F. in NTU	Remarks
0.0	7.5	1.1	1.4	
2.0	7.2	1	1.2	
4.0	7.1	0.9	1.1	
6.0	6.6	0.7	0.9	
8.0	6.2	0.5	0.8	
10.0	5.9	0.9	1.1	
12.0	4.9	1.1	0.8	
13.5	4.5	0.9	1.1	End of filter run of conventional RSF (media chocked)
14.0	4.4	--	1.4	
16.0	4.2	--	1.9	
18.0	3.9	--	2.4	
20.0	3.7	--	3.1	
22.0	3.8	--	3.7	
22.5	3.9	--	3.8	End of filter run of capped RSF (break through)

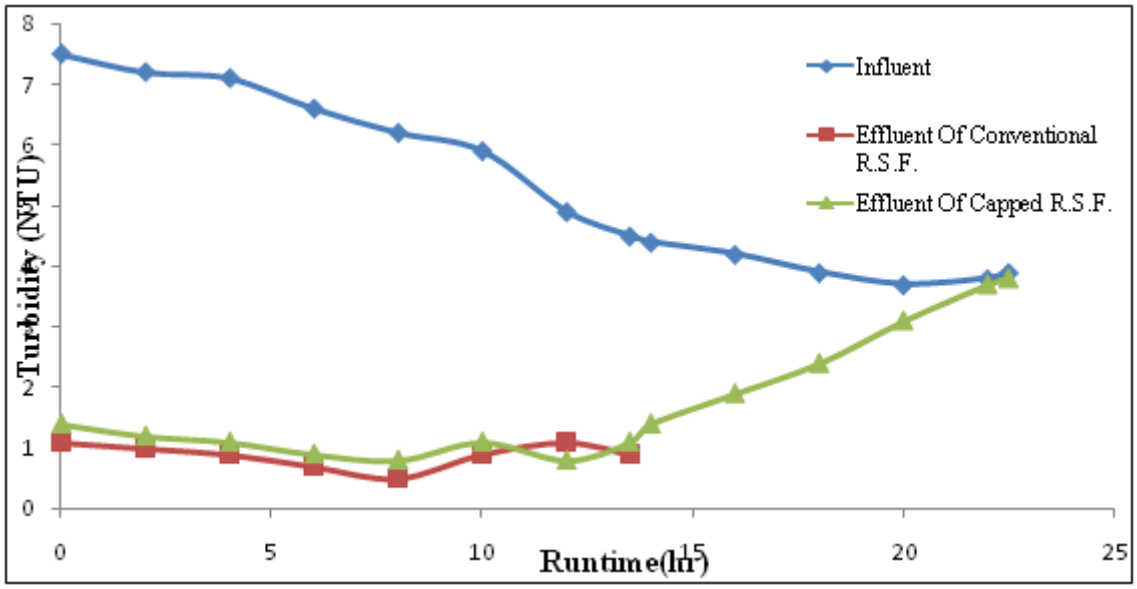

Figure 3: Comparison of performance of Conventional R.S.F. and Coconut shell capped R.S.F. (For first filter run)

Table 2: Turbidity removal in second filter run at an increased filtration rate of 7m/hr for capped RSF against filtration rate of 5m/hr for conventional RSF

Time in hr	Turbidity of influent in NTU	Turbidity of effluent of conventional R.S.F. in NTU	Turbidity of effluent of capped R.S.F. in NTU	Remark
0.0	3.9	0.9	1.1	
2.0	4.2	0.8	1	
4.0	4	0.9	0.8	
6.0	4.2	1	0.9	
8.0	3.9	1.1	0.8	
10.0	3.2	0.8	1.1	
12.0	3	0.9	1.2	End of filter run of conventional RSF(media chocked)
14.0	3.2	--	1.9	
16.0	3.3	--	1.9	
18.0	3.5	--	2.5	
20.0	3.4	--	2.4	
22.0	3.2	--	2.9	
23.0	3.3	--	3.1	End of filter run of capped RSF(break through)

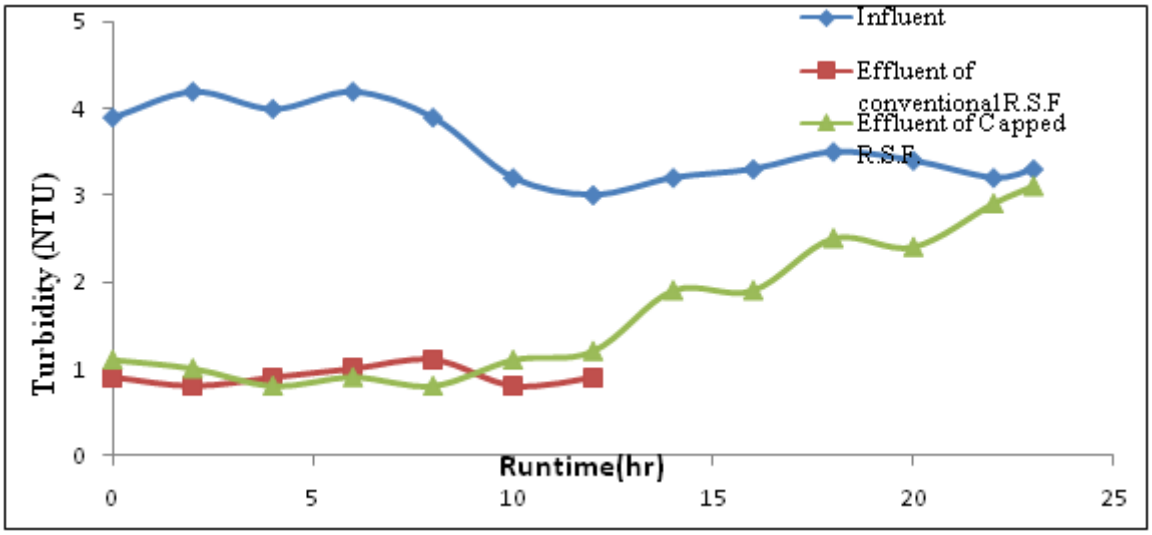

Fig.ure 4: Comparison of performance of Conventional R.S.F. and Coconut shell capped R.S.F. (For second filter run)

Table 3: Backwash periods

Back-washing time in minutes	Conventional RSF		Capped RSF		Remark
	Turbidity of back wash influent (NTU)	Turbidity of Back wash effluent (NTU)	Turbidity of influent (NTU)	Turbidity of effluent (NTU)	
0	2.9	63	3.2	68	
5	2.9	39	3.2	20	
10	2.9	21	3.2	3.2	Backwash completes for capped RSF.
15	2.9	3.0	--	--	Backwash completes for conventional RSF.

Table 4: Comparison of conventional R.S.F. and Capped R.S.F

Sr. no.	Parameters of comparison	Conventional R.S.F.	Capped R.S.F.(using 10cm coconut shell as capping)
01	Filter media	Sand (eff. Size 0.6mm, Cu-1.7,Depth-60cm)	Sand (eff. Size 0.6mm, Cu-1.7,Depth-50cm) Coconut shell(eff. Size 1.91mm)
02	Rate of Filtration	5m/hr	5 to 7m/hr
03	Filter Run	12 to 13.5 hr	22.5 to 23 hr
04	Period of Backwash	15min.	10min.
	(To wash pilot column.. 80cm rise/minute)		
05	Amount of wash water (To wash pilot column)	270 liters	180 liters

5. Conclusions

From the study made to evaluate the effect of capping of RSF following conclusions were made;

a) The capping of RSF using the crushed coconut shell as capping media can increase the filter run by about 80%.
b) Higher rate of filtration can be obtained after capping without much effect on the filtrate quality.
c) Backwash requirement for capped RSF is less as compared to conventional RSF by 33%.
d) Capping of conventional RSF can be very effective tool in case of overloaded conventional plants where higher rate of filtration can be possible without much modification.

6. Future Scope

Capping with coconut shell proves very effective in improving performance of rapid sand filter in pilot scale. This material should be tested for full scale plant to access its suitability for mass scale filtration. Use of filter with coconut shell as capping media for longer period will give better

performance analysis. The intense study on the total life of such capping media as compare to the normal life of sand media used conventionally has also to be done.

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