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Experimental Evaluation of Gravel Bed Up-Flow Roughing Filter for Pre-Treatment of Rural Community Water Treatment

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Abstract

Water is essential for life. This study evaluates gravel bed up-flow roughing filter (URF) for pre-treatment of rural community water treatment. The pilot unit consisting of acrylic pipe with internal diameter 90mm was used for study. This column is vertically fixed, having an inlet at bottom so that filter can be run for up flow mode of operation. For sake of roughing filtration, artificial raw water was continuously passed through laboratory column packed with quartz gravel media. Media size range was 16mm-2.36mm. The media was filled in the column in three layers. Filter was studied for the flow rates in the range of 5-20m/hr. The results investigated shows that turbidity removal by gravel bed roughing filter is very good it is almost 85% - 90%. By and large, based on the present experience of the different filtration experiments it can be certainly inferred that the URF is a dependable alternative for conventional pretreatment of water in rural community water treatment.

Keywords: URF; Rouging filter; Water treatment; Gravel media

Introduction

The development of human settlements cannot be assured without securing and maintaining an adequate supply of water. Naturally availed water can contain a wide range of ingredients that can make people awkwardly ill or make it unsuitable for certain applications. So, ensuring appropriateness of water in view of a proposed use is an inevitable task. The necessity of water purification was understood by man at the very outset of civilization. Wholesome water is one which is safe, potable, and contains essential nourishing minerals in adequate quantity. So the quest for progressively better water continues.

However, an increase in manmade water pollution, the development of technical and public health science, as well as the consumer's greater need for clean water contributed to the development of the water purification technology [1].

Water, as required for the life, is rarely available in the natural world. Therefore, wide arrays of treatment procedures are evolved to cope up with different quantities, initial qualities, and finishing requirements of water to be treated. In the present day, the main objective of water treatment facilities in India is to produce safe and potable water. With ongoing development of the country it will be obligatory to address the issues related with safe, potable and wholesomeness of water to be supplied and sustainability of treatment procedures to be followed.

Contemporary water treatment technology is the outcome of vigorous and systematic efforts of scientists and technologists, working for more than last hundred and fifty years. Surface water assumed the status of prime source of water as it is more suitable for the use, and easier to treat in comparison with water from other sources such as ground water or sea water. So, from the 1850s to about the 1950s, water treatment facilities were frequently designed by experienced engineers using empirical rules and succeeded design practices. However, after the 1950s, a greater understanding of fundamental principles underlying treatment processes was required to deal with complexities due to growing demand for water, and increased pollution of water bodies.

Pretreatment comprising of coagulation, flocculation and sedimentation is known to be essential for rapid sand filtration. It is because pretreatment not only trims down the particles but reduces the surface charges of micro flocs to be removed by final filters. However, the conventional pretreatment is costlier in view of large capital as well as operation costs. Therefore, there is a need for alternative pretreatment methodology to replace conventional pretreatment units. Roughing filtration (RF) are low-cost primary treatment options that could potentially improve the water quality. The goal is that the primary treatment reduces the turbidity to be within the 5-10 NTU range or lower so that RSF can be effective.

A roughing filter can effectively remove colloidal-size particulates without the addition of coagulant chemicals and also provide a large solids storage capacity at low head loss. Sedimentation and adhesion to media particles are the main particle removal mechanisms [2]. So, Roughing Filtration could be considered as dependable technique for pretreatment. Subsequent to study of many water treatment plants in India, CPCB [3] reported rather inadequate pretreatment at many plants. It is reported that chemical feeding is unsatisfactory, flash-mixers are defunct and settling basins are overloaded. The use of roughing filtration would obviate need of flash mixers and settling basins.

Depending on the rate of filtration, filters can be classified as slow sand filters, rapid filters, or high rate filters. Due to common availability, sand and gravel are the most common granular media. Mono-medium, dual media and multimedia filters are also developed to enrich the filtration process. Direction of flow during filtration process results in different types of filters as down flow, up flow, horizontal flow, radial flow and bi-flow filters. Filters utilized in water treatment are also classified as gravity or pressure filters based on driving force. Pre-filters or roughing filters primarily aim at removal of impurities basically larger in size and provide pretreatment to reduce the load on final polishing filters. Significant aspects, design and operational parameters of the commonly used of filters and roughing filters are provided in Table 1.

Table 1: Significant aspects of the commonly used of filters and roughing filter.

Parameter	Slow Sand	Rapid	High Rate	Roughing
Filtration rate	0.05-0.2m/h	5-15m/h	15-30m/hr	(Before S. S. F.) 1-3m/hr.; Could be more if before R. S. F.
Direction of Flow	Downwards	Downwards, Up-flow	Downwards, Up-flow	Horizontal, Vertically upwards or downwards
Media	Mono-medium Sand	Mono-medium Sand/ Dual media Sand + Coal	Mono-medium Sand/ Dual media Sand + Coal	Gravel and boulders
Application for Treatment of	Drinking water	Drinking water/ Industrial water/ Waste water	Industrial water/ Waste water	Pretreatment for Drinking water, Storm water
Media diameter	0.3-0.45mm	0.5-1.2mm	0.8-2mm	(2-100mm)
Bed depth	0.9-1.5m	0.6-1.8m	0.6-1.8m	Horizontal: several m .Vertical: up to 1.5m
Required head	0.9-1.5m	1.8-3.0m	1.8-3.0m	0.9-1.5m
Run length	1-6 months	1-4 days	1-4 days	Several days
Ripening period	Several days	15 min-2h	15 min-2h	15 min-2h
Pretreatment	None required	Coagulation and settling	Coagulation and settling	Sometimes Coagulation
Dominant mechanisms	Straining, biological activity	Depth filtration		Straining, Settling, intercepting
Regeneration	Scraping	Back washing	Back washing	Draining, hosing
Maximum raw water turbidity	10-50 NTU (Desirable<10 NTU)	Unlimited with proper treatment (Desirable<10-15 NTU)	Unlimited with proper treatment (Desirable<10-15 NTU)	Unlimited

Conventional Water Treatment Units

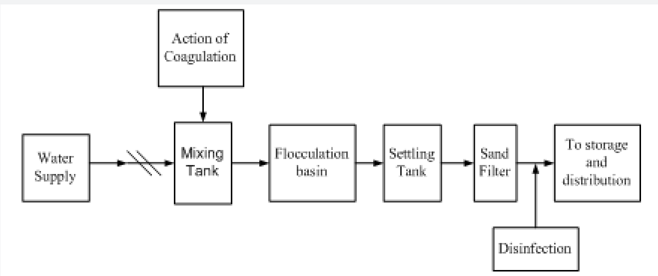

Figure 1: Conventional Water Treatment System.

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In reference [4,5] the primary purpose in surface-water treatment is chemical clarification by coagulation and mixing, flocculation, sedimentation, and filtration. These unit processes along with disinfection work to remove particles, naturally occurring organic matter (bacteria, algae, zooplankton, and organic compounds), and microbes from water to produce quality water that is noncorrosive. Specifically, coagulation and flocculation work to destabilize particles and agglomerate dissolved and particulate matter. Sedimentation removes solids and provides virus removal. Filtration removes solids and provides 1-log virus removal. Finally, disinfection provides microbial inactivation and 2-log virus removal Figure 1.

Simply stated, water primary treatment is any physical, chemical, or mechanical process used before main water treatment processes. It can include screening, pre sedimentation, and chemical addition.

Non-Conventional Pretreatment Units

The electro coagulation floatation process consists of electrolytic reactor with aluminum electrodes and a separation floatation tank. The colloidal particles present in the water are subjected to coagulation and flocculation by aluminum ions dissolved from the electrodes. Hydrogen gas generated at cathode floats the flocs [6]. Performed experiments on laboratory setup and concluded that electro-coagulation performed better than conventional coagulation with aluminum sulphate for treating a model colored water, 20% more DOCS was removed for the same Al dose.

Kardile [7] has worked on a new unconventional treatment plant at Varangaon. The system was designed for daily water supply of 4.20 MLD. He introduced gravel bed flocculation unit of 3m*3m*2.5m in water treatment plant. Gravel bed flocculation provides a promising solution to replace mechanical flocculation unit for treatment of turbid water sources for small capacity plants.

Bhole et al. [8] have introduced “New concepts in low cost treatment plants”. They conducted experiments on pretreatment unit which combines principles of tapered velocity gradient flocculation and solids contact flocculation.

Background on Roughing Filtration

Wegelin [1] points out that roughing filtration is a process for separating suspended impurities from water by passing through porous media. Particle removal is one of the main objectives of filtration. Gravel filtration has been used in water treatment since the early 1800s, when it was first used in Scotland to pre-treat water prior to sand filtration. Gravel filtration soon disappeared due to the advent of chemical and mechanical water treatment. However, gravel filtration reemerged in the 1970’s and 1980’s mainly in developing countries as roughing filters, because those roughing filters do not require sophisticated mechanical equipment or the use of chemicals.

Wegelin [1] mentioned, roughing filtration technology is used as primary treatment to polish the raw water quality for the improvement of performance of slow sand filtration. But it may be used without slow sand filtration, if raw water originates from well protected catchment area and having minor bacteriological contamination. Therefore in rural water supply systems roughing filtration becomes an appropriate technology.

So far theory of roughing filtration is not amply established as the roughing filtration is not employed widely. It is being considered as a remedial measure to reduce turbidity of water to be applied to slow sand filters. Presently, the slow sand filtration is almost abandoned in view of increased water demand and large area needed for it. However, the roughing filtration could be employed for rain water harvesting as well as an alternative for conventional pretreatment. Ease of operation and maintenance in roughing filtration makes it appealing for small capacity water treatment plants in rural area.

As the pore sizes in roughing filter media are quite larger than media in all other granular filters, head-loss developments are smaller and the filter can run for more duration. So, the regeneration is required less frequently. However, the regeneration of roughing filter is rather distinct in comparison with other granular filters. The larger media grains need too large flow rates for fluidization. So, the cleaning by draining the bed is adopted at many places. Smaller gravel in roughing filters could be cleaned by fluidized washing. Suitable techniques could be appropriately combined to regenerate roughing filter as and when required.

Materials and Methods

In pursuance of set objectives for the present work, laboratory experiments were planned and performed.

Figure 2 shows the schematic representation of the pilot plant unit and Figure 3 shows an actual picture of the filter unit.

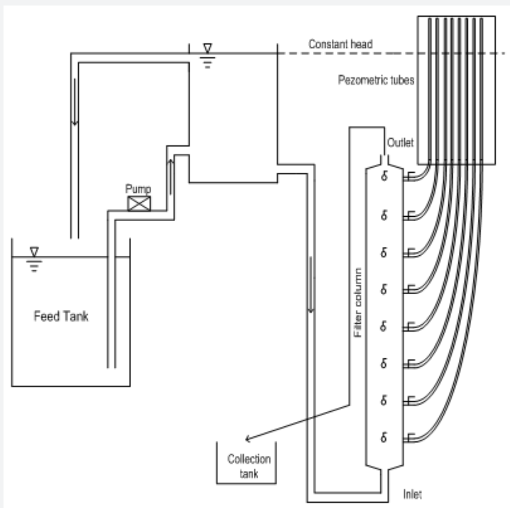

Figure 2: The Schematic Representation of the Pilot Plant.

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Figure 3: Actual Picture of the Filter Unit.

Experimental setup

Filter column: The filter column used for laboratory experiment is an acrylic pipe with internal diameter 90mm. This column is vertically fixed, having an inlet at bottom so that filter can be run for up flow mode of operation. For sake of roughing filtration, artificial raw water was continuously passed through laboratory column packed with gravel media.

In order simulate field conditions constant head tank is provided. The artificial influent from feed tank is pumped to the constant head tank. The overflow from the constant head tank is allowed to pass into feed tank. So, the artificial clay suspension in feed tank was in incessantly stirring condition due to pumping and recirculation from constant head tank and there was almost no settling in feeder tank.

Layer	Media Size Range and Porosity	Images of Media
Bottom Layer Thickness for Alternative A –60 cm Alternative B – 60 cm Alternative C –60 cm	16 mm – 12.5 mm Porosity – 45%	
Middle layer Thickness for Alternative A –60 cm Alternative B – 30 cm Alternative C –40 cm	12.5 mm – 4.75mm Porosity – 44%	
Top Layer Thickness for Alternative A – Nil Alternative B – 30 cm Alternative C –20 cm	4.75mm – 2.36mm Porosity – 42%	

Figure 4: Media Configuration Tried for Filter Bed.

Filter media: Media used for filter bed is quartz gravel. Media size range was 16mm-2.36 mm. Stratification and configuration tried was as shown in Figure 4. The media was filled in the column in three layers. Prior to packing each layer in column, filter media was washed thoroughly with tap water. Media was packed in the column in 5 cm increments and tamped down before pouring additional media. After each layer of filter media a temporary perforated plate was placed on and pressed tightly against the top of the filter media.

Head loss and sampling ports: The filter column has 8 sampling ports as well as 8 ports for determining head loss at various depths of media. The inlet port is at bottom and first sampling port is provided at a distance of 20cm from inlet port and other successive ports are arranged accordingly. The seventh port is at the top of the filter followed by output.

Flow control arrangements: A centrifugal (0.25 hp) pump is used to pump the influent water from the feeder tank to the constant head tank. Constant head arrangement is provided by allowing overflow from constant head tank. The overflow from constant head tank is again directed to the feeder tank.

Flow rate arrangements: The filter was run at the constant flow rate. A flow control valve at the outlet of the column is used to control of flow rate.

Characteristics of water used: For the present study, bore water and river bank clay was used to prepare artificial influent. The bore well water was used for fluidized washing as well as for Back-flushing the filter bed as and when required.

Suspension of river bank clay: For the experimental study, artificial turbid water prepared in laboratory was used. The turbidity was created by adding river bank clay to bore well water. Prior to each experiment, the clay was hydrated in bore well water overnight, dispersed in a blender, and mixed with additional water to the desired initial turbidity.

Coagulation: Alum was used as coagulant. The stock solution of alum was prepared in distilled water. It was added in feeder tank in predetermined doses and mixed thoroughly every time while preparing influent as desired for each set of filtration experiment. As overflow water from constant head tank was re-circulated into feeder tank, there was continuous agitation and the possibility of settling of particles in the tank was reduced. Further the stirring condition also helped for better mixing of coagulant with raw water. The doses were determined by conducting standard jar test.

Measurements of parameters

Turbidity measurements: Removal efficiencies for all experiments were based on turbidity measurements (NTU). All turbidity measurements were directly done, using a digital turbidity meter of Hach make (2100P Portable Turbidimeter).

Flow rate: Flow rates were determined by collecting effluent in calibrated jar and recording time required for collecting 1 L of effluent in the jar. Flow rates were determined at the predetermined time interval i.e. every one hour.

Head loss: The head loss measurements were carried out and recorded at every hour and at all ports of filter column. Piezometric tubes were used to measure head at each port.

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Results and Discussion

Various filtration experiments were conducted in order to acquire experience regarding performance of the roughing filter. The observations made are put forth in this chapter along with the discussions and significant findings.

Design of experimental set-up and operational parameters studied

Design of experimental set-up and operational parameters are of immense importance in the study as they determine rationality of findings based on the study. So, the design of experimental set-up and operational parameters were carefully considered.

Filter bed adopted: The configuration of filter bed is the essence of all filtration processes. The characteristics of filter media and depth of filter bed govern the crucial parameters. The quartz gravel was used in the present study. In line with the aim of pre treating the turbid water the coarser media (2.36mm-16mm) was selected unlike the finishing filters where effective size of sand used is about 0.5 mm. As in the present study the URF was challenged with coagulated and flocculated influent the largest gravel size adopted was 16mm.

The stratified filter bed was adopted unlike the finishing filters wherein un-stratified bed is deployed. For finishing filters stratified bed are avoided in order to get rid of intermixing at the media interfaces which can produce higher head losses. Further highly fluidized washing of URF is to be never tried due to larger media grains which require unworkably large fluidizing velocities. So, the stratified bed was adopted with three different layers with gravel size ranges as 2.36-4.75mm, 4.75-12.5mm and 12.5-16mm. The layer depths were optimized to avail optimum removal performance as discussed in subsequent sections. The total depth of 1.2 was adopted in the present study.

Flow rates rtudied: The flow rates to be deployed depend on target effluent, quality of influent, and more crucially on economic feasibility. Good quality of target effluent and poor quality of influent demand lower flow rates whereas greater economic feasibility would demand higher flow rates. In this view the flow rates in the 5-20m/hr were tried in the present study. Earlier studies for roughing filtration are carried out even with flow rates of 1m/hr for pretreatment of water to be applied on slow sand filters Wegelin [1]. Considering increased water demand, the aim to accomplish only pretreatment, set target turbidities and more decisively economic interests the flow rates adopted in the present study could be proclaimed to be appropriate.

Optimizing filter bed configuration

For finding optimum media configuration, different combinations of different sizes of gravel media were tried. The total depth of media in URF column was 120 cm as aforesaid Wegelin, [1]. The different configuration of media as considered in alternatives A, B. and C were tried (Figure 4). The filter runs were conducted with influent turbidity of 20-100NTU and a coagulant dose of 5-40mg/L. Constant flow rate of 15±0.4m/hr was applied. It is desired to have effluent turbidity below 10 NTU.

Although effluent turbidities observed for the alternative B, are superior to some extent for all filter runs, the total head-losses for the alternative B are significantly larger. The head losses after6 hr for the alternative B is 40-55% larger than for the alternative C. So, the configuration - alternative C is considered as the best configuration as the removal efficiency was as desired and head- loss development was considerably less in comparison with the configuration alternative B (Figure 5).

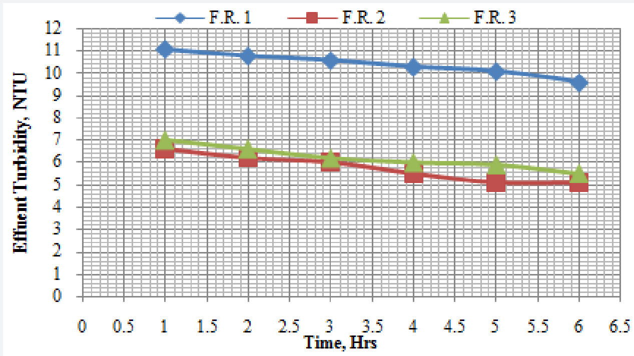

Figure 5: Effluent turbidity Vs Time.

Clean bed head-losses

Clean bed head-losses, also known as initial head-losses are amongst the significant hydraulic focuses that are relevant to design of filtration systems. Depth-wise initial head-losses are informative in respect of stratification of filter bed. Further, initial head-losses influence the head available for actual filtration. Initial head-losses across the filtration system are inclusive of losses in the system without filter bed i.e. piping with accessories and filter bottom with under-drains. Therefore they are also useful to evaluate system components other than the filter bed.

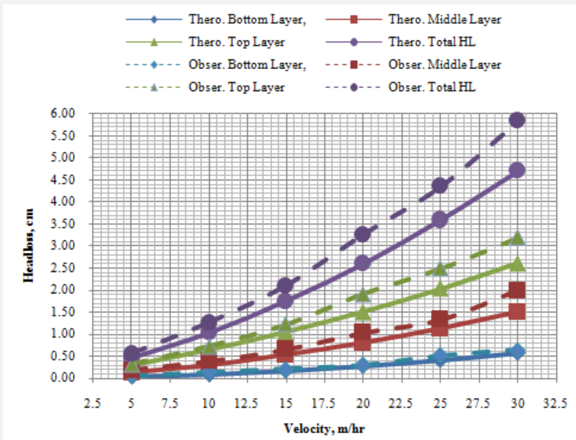

Figure 6: Clean Bed Head Losses; Observed and Theoretical.

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These losses are found to vary nonlinearly and are directly proportional to flow rate. The clean bed head-losses for the URF layers with larger media grains were lower than that for layers with smaller media grains due to larger grain sizes and porosity of the UF filter. Theoretical clean bed losses, calculated using Ergun's equation, are compared with observed head losses.

The observed initial head-losses for different flow rates, at different depths of sand beds are plotted in Figure 6 the depths considered are measured in the direction of the flow through gravel media. The observed initial head-losses are marginally higher than computed head-losses for all layers as apparent from Figure 6.

Ripening behavior of filter

This first stage of maturation of filter is known as ripening. During the process of ripening the clean filter bed gets conditioned due to attachment of particles from influent. The removal efficiency of a filter continues to improve as the deposits build up in media during ripening period.

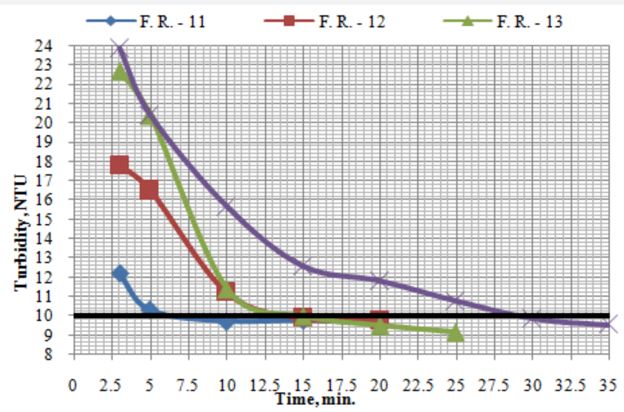

Figure 7: Dependence of Ripening on flow rate.

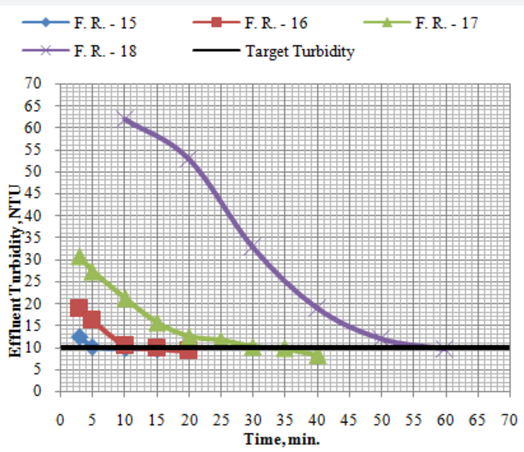

Figure 8: Dependence of Ripening on Influent Turbidity.

In general ripening periods observed for URF are 15min-1hr. Similar to those for finishing filters (15min-2hr). Though grain size in URF is large ripening periods are comparable with finishing filter because of high target turbidity for URF i.e. 10 NTU (for finishing filters target turbidities are lower i.e. 1 NTU in line with current drinking water standards [9] As seen from Figure 7 the ripening of URF is dependent on filtration rate which corroborates with the earlier research on ripening of rapid sand filters, Cranston and Amirtharajah [10]. So, in order to deal with inadequate effluent during ripening period it advisable to re-circulate the inadequate effluent and to provide multiple units of URF operating in staggered manner Figure 8.

Effect of flow rate on removal efficiency and head loss development

For determining optimum flow rate for URF, removal efficiency and head loss development are crucial. Hence, the filter runs on URF were carried out to study effect of flow rate on removal efficiency and head loss development. URF was run for 6hrs. Flow rates were varied from 520m/hr and different influent turbidities were tried (25-100 NTU) with the respective coagulant doses. It was desired to have effluent turbidity below 10 NTU.

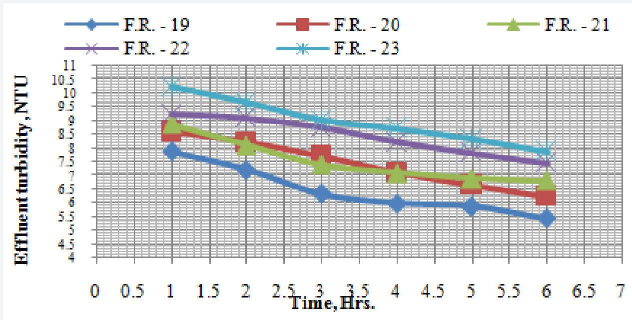

Figure 9: Effect of Flow Rate on Removal Efficiency for I.T. of 25±2 NTU.

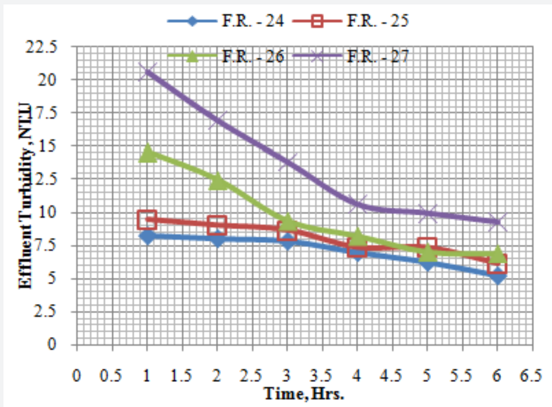

Figure 10: Effect of Flow Rate on Removal Efficiency for I.T. of 50±3 NTU.

Observations for influent turbidity 25±2 NTU and 50±3 NTU are illustrated in Figure 9,10. In general it is found that with increase in flow rates removal efficiencies reduce and head losses increase. Since desired turbidity is 10 NTU and URF is found to take more than reasonable time for ripening at higher

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flow rates. So, for higher turbidities the only option is to run the URF at lower rate (5m/hr.). However such higher turbidities are for very small period during the year. For the normal turbidity as seen from the different runs discussed earlier, flow rate of 15m/hr. is found to be reasonable in order achieve desired removal performance. With this flow rate, filter will generate more amount of effluent/sqm, so that, overall cost of treatment will be more affordable.

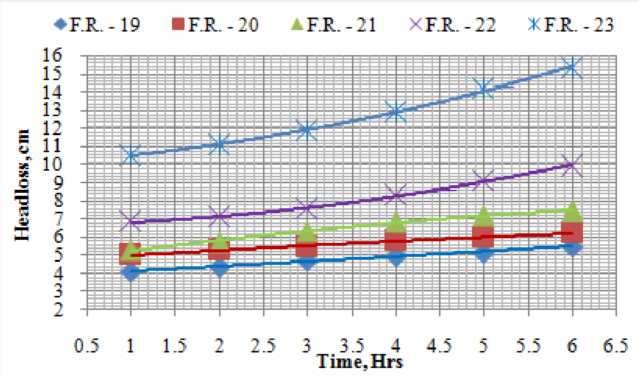

Figure 11: Effect of Flow Rate on Head Loss Development for I.T. of 25 ± 2 NTU.

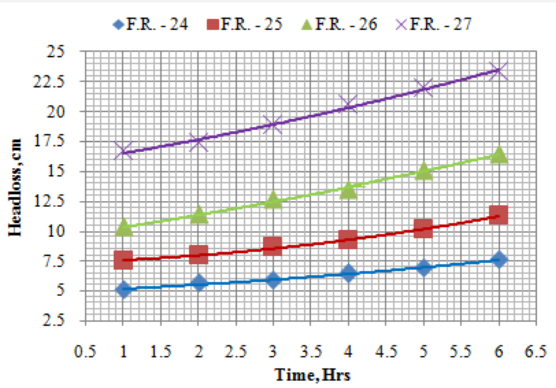

Figure 12: Effect of Flow Rate on Head Loss Development for I.T. of 50 ± 3 NTU.

Observing Figure 11,12 it can be seen that for smaller flow rates i.e. 5m/hr and 10m/hr head losses are low enough whereas for higher flow rates, like 20m/hr and above, head losses are too high. Keeping in mind head-loss development too, constant flow rate of 15±0.4m/hr is recommendable for URF.

Performance evaluation of URF with optimal design and operating parameters

To evaluate performance of the URF unit, effluent turbidities and head losses at different level and at different time intervals are very expedient. Further, an experience of long duration runs is essential for advocating the technique for field use. Keeping this in mind the URF was run for longer duration and turbidity and head-losses are monitored at different levels and periodically by collecting samples at the sample ports. The filter runs were conducted with influent turbidity of 20-100NTU and a coagulant dose of 5-40mg/L. Constant flow rate of 15±0.4m/hr was applied. It is desired to have effluent turbidity below 10 NTU (Figure 13-15).

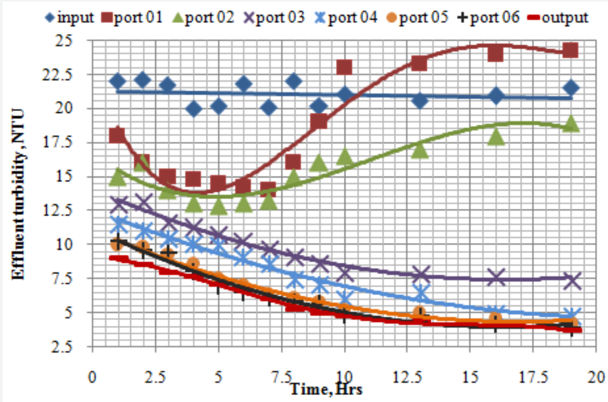

Figure 13: Port Wise Removal Efficiency for Longer Run (for 19hrs run with influent turbidity 20±3 NTU and flow rate of 15 ± 0.4m/hr).

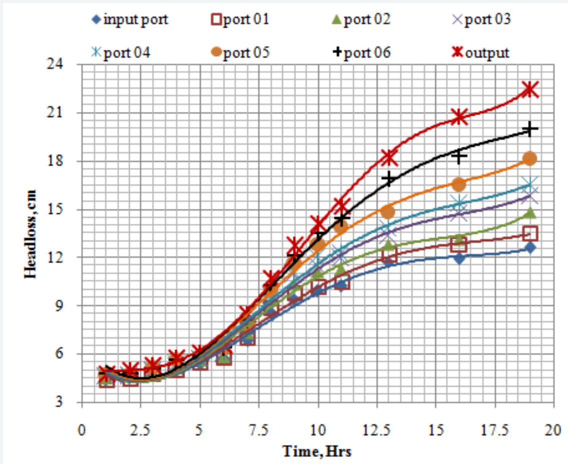

Figure 14: Port Wise Removal Efficiency for Longer Run (for 19hrs run with influent turbidity 20±3 NTU and flow rate of 15 ± 0.4m/hr).

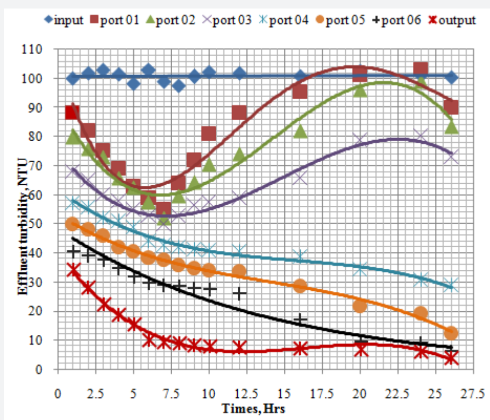

Figure 15: Port Wise Removal Efficiency for Longer Run (for 26 hrs run with turbidity ranging between 100±5 NTU and flow rate of 15±0.4m/hr).

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The port wise turbidities were monitored during filter run (F. R.) with influent turbidity 20±3NTU. Constant flow rate of 15±0.4m/hr was employed. The F. R. was carried out for 19 hrs. The average effluent turbidity obtained was 4.2 NTU. So, the removal performance was good enough in view of target turbidity set (10 NTU). The total head loss developed was 22.5cm after 19 hr therefore the run could have been extended further, as the effluent turbidity was also significantly less than target turbidity.

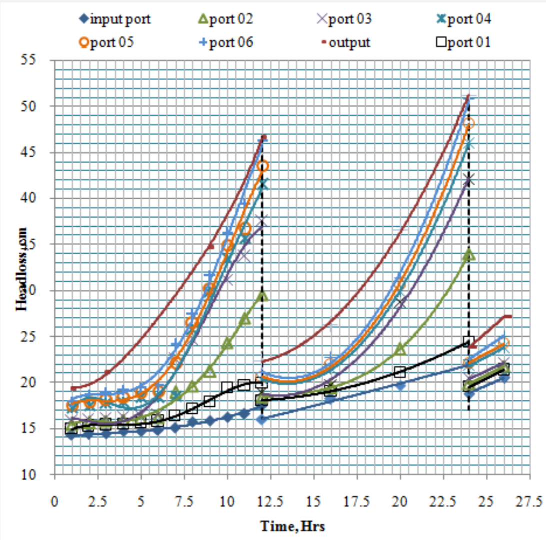

Figure 16: Effect of Back-flushing on Head loss (for 26 hrs run with influent turbidity100±5 NTU and flow rate of 15±0.4m/hr).

As seen from Figure 16, it can be understood that turbidity removal is throughout filter depth, though it is more significant in middle lower portion of total media.

For some other F. R., URF was operated for duration of 26hrs; and during this time interval port wise turbidities were monitored (Figure 15). Back flushing was adopted after ever 12 hrs for improving performance of URF for this filter run. While operating this filter run influent turbidity of 100±5 NTU and constant flow rate of 15±0.4m/hr was employed.

Observing trend of turbidity removal in this filer run, it can be understood that after each back flushing interval (i.e. every 12 hrs) there is moderate change in removal efficiency of URF. However, as filter run proceeds turbidity keeps on decreasing. The Figure 16 gives relationship between head loss and time. Here also effect of back flushing can be seen notably. After each back flushing phase there is fall in head-loss and gradually it increases. The recovering of utilized head has significantly positive impact since it helps in extending duration of filter run and periodic back-flushing assists in keeping the bed reasonably clean. At the end of the filter run maximum head loss observed after 26hr was just 27.1cm. Periodic back flushing is required to prevent heavy accumulation of solids in the roughing filter. This will reduce deterioration of effluent due to detachment and in minimizing head losses too.

Conclusion

Based on the present study, it is feasible to render certain inferences regarding behavioral aspects of URF, deployed as an alternative for pretreatment of water. Further, the recommendations for design and operating parameters for URF are also put forth based on the experience of performance URF.

General features of URF

- Up flow roughing filtration is found to be viable for pretreatment of water. The URF is found to function consistently for long duration without special requirements of operating skills. So, the present study corroborates its deployment in rural water supply schemes where treatment plant capacities are small; and skilled operators not available.

- The URF demonstrated true depth filtration as head loss developments were moderate and there was no incidence of clogging of the bed.

- Clean bed head losses are insignificant in URF due to large grain size and porosities. Theoretical head losses computed using Ergun's formula, are comparable with observed head losses.

- The initial effluent quality was found to be poor during ripening. Ripening periods are found to be reasonably smaller (3min) for lower flow rates (5m/hr) and lower influent turbidities (26±0.5). Ripening periods are found to be larger (60min) for larger flow rates (20m/hr) and larger influent turbidities (100±1).

- Head losses in URF during operation are inversely proportional to flow rate and directly proportional to influent turbidity. However, the head-loss development in UFR is moderate due to large grain size and porosities. In general head loss is not the run termination criterion for URF.

- The head lost during operation can be recovered through back-flushing periodically. So, back-flushing results in extending the URF runs.

Recommendations for design and operating parameters for URF

The URF bed configuration is recommended as follows Table 2.

Table 2: The URF bed configuration is recommended as follows.

Bottom layer	0.6m, Gravel - 16-12.5mm
Middle layer	0.4m, Gravel - 12.5- 4.75mm
Top layer	0.2m, Gravel - 4.75- 2.36
Type of bed	Stratified

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Operating parameters are recommended as follows Table 3.

Table 3: Operating parameters are recommended as follows.

Influent	Common (20±3 NTU)	Occasional (100±5 NTU)
Flow rates, m/hr	5 to 15	5
Coagulation Dose*, mg/ L	5	40
Hosing, and Back-flushing	Every 12hr.	Every 12hr.
*- In absence of jar test.		

References

1. Wegelin M (1996) 'Surface Water Treatment by Roughing Filters a Design, Construction And Operation Manual' Swiss Federal Institute for Environmental Science and Technology (EAWAG) and Department Water and Sanitation in Developing Countries (SANDEC), Switzerland.
2. Schulz CR and Okun DA (1984) 'General overview of rapid sand filtration Surface water treatment for communities in developing countries', IT, London.
3. CPCB Moef Govt of India (2008) Status of Water Treatment Plants in India Central Pollution Control Board India.
4. Howard S. Peavy and Donald Rowe (1985) Environmental Engineering, Mcgraw Hill.
5. Garg SK (1977) Water Supply Engineering, KP Publisher, Delhi, India.
6. Jiang Jia-Qian, Graham Nigel, Cecile Andre, Geoff H. Kelsall and Brandon Nigel (2002) 'Laboratory Study of Electro-Coagulation Floatation for Water Treatment, Water research 26(1): 4064-4078.
7. Kardile JN (1978) 'Development of Simple and Economic Filtration Methods for Water Supplies' P h.d Thesis, Nagpur University, India.
8. Bhole AG and Ughale VA (1981) 'Study of Surface Contact Flocculator' Journal of American Water Works Association 13(2): 179 – 183.
9. IS 10500 (2012) Drinking Water-Specification Bureau of Indian Standards, New Delhi, India.
10. Cranston KO and Amirtharajah A, J AWWA (1987) Improving the Initial Effluent Quality of a Dual Media Filter by Coagulants in Backwash 79(12): 50.

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