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Investigation of Roughing Filter Efficiency on Turbidity and Parasite Egg Removal from Raw Water

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ABSTRACT

Slow Sand Filters are as a proper technology for pre-treatment of raw water, with a fine and medium trubidity in small communities in developing countries. Thus, with a minimum operation cost and minimum need for expest bodies have the maximum efficiency. The purpose of this research is carried out to evaluate the efficiency of two processes of horizontal flow roughing filter and vertical flow roughing filter, in order to remove the trubidity and parasite egg from water. For this purpose, two series of pilots are used, each pilot has 3 sections, which consists of granular particles of 4-25 mm. First section of each filter is filed with the granuls of 12-18 mm in diameters. Second section of each filter also contains with sand of 8-12 mm in diameters and the third section of each filter also contains with the sand of 4-8 mm in diameters. The head sections 1, 2 and 3 were 1 meter in down flow roughing filter, respectively. Samples of turbid water, which were made artificially (silty soil + water) and sample waters with different turbidities were injected into two systems and since on of the other goals of research was to study the efficiency of these filters, in removal of parasitic egg from water, therefore from the total concentrates which were prepared from parasitic eggs; such as:*Ascaris*, *Fasicola hepatica* and *Trichosephal* and water was added to them. These samples were finally passed through filters. The outcomes of the study, indicate that accelerating the filteration process, leads to declined efficiency of both filters. Horizontal flow roughing filters also have a higher efficiency compared with medium and fine media filters, in removing trubidities, in such manner that these filters are able to treat and refine waters with turbidities of 500-1000 NTU which vertical flow roughing filters, are only able to receive waters with turbidities up to 150 NTU.

INTRODUCTION

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Water resources of human communities include surface and ground waters. Turbidily and the degree of bacterial pollution are key parameters, in explanation of the quality of raw effluents. These parameters are most important pollutants of surface water resources (2). The majority of surface waters contain huge amount of suspended and colloid materials; such as particles of clay, silt, asbestos, organic chemicals and micro organisms, which can cause problems in regard to their sanitation and transparency. For this reason, treatment of the majority of these sources are necessary (1). Usual methods for treatment of surface waters need huge capitalizations and abundant chemicals to be applied, while experts should be recruited and gain access to all of the 3 abovecases in developing countries, especially in small cities and rural areas, with limited budget and facilities, making the potential materialization of the said 3 cases rather impossible and difficult (14). Slow sand filters provide an appropriate technology for treatment of surface waters (11,12). These filters are the most effective, the simplest and cheapest filters for treatment of surface waters in urban and rural regions of developing countries (17). One of the main defects of these filter is their sensitivity to huge loads of suspended solids and their high turbidity (18); in such manner that water contains

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frequency in it's exploitation (5). The frequency of clearing filters have a significant impact upon exploitation costs, in such manner that enhancement of the number of filters cleaning promotes intensifies exploitation expenses (15). On the otherhand, if water contains particles of clay these particles penetrate in depths of the filter, and makes their cleaning by removal and dredging(10). If the turbidity of raw effluents entering the filter within several weeks is higher than 50 NTU, pre-treatment of water shall be necessary (20). The recommended turbidity for appropriate application of a filter is less than 10 NTU, while some alternative references state the scope of acceptable turbidity of the inlet water to the slow and filter being from 5 to 20 NTU (14,16). Different processes exist for pre-treatment of water and their most common processes include waste collection chemical treatment, preliminary edimentation, microstrines pre-filteration and floatation (16). The features of the pre-treatment processes, stated above being summarized in Table 1(17). Among pre-filteration processes, dynamic filters water basin filters and roughing filters are enamed as appropriate means for pre-treatment of highly turbid waters with a minimum need for exploitation rate (18). Practical previous experiences, manifest that roughing filters are able to remove 98 to 99 percent of suspended solids from surface water resources. Additionally, they can promote the bactriological quality of water. Usually, 1 to 2 logarithms leads to ageneral decline of faces forms in these reported filters. These filters are capable of lowering it's general concentration forms from 40000 CFU/100 cc to 400 CFU/100cc and lower the concentration of it's suspended solids from 90 mg/l to 5 mg/l (1) and the subject of this project is horizontal flow and down flow roughing filters (2). Table 1 and 2 shows the application of some conventional features of pre-treatment processes (2).

MATERIALS AND METHODS

In order to study the goals of the investigating and to scrutinize horizontal flow roughing filteration and down flow roughing filteration in removal of turbidity and parasitic eggs from water and to study the impact of granulization of the bedding upon the efficiency of both processes two pilot units were applied in series. Each pilot consisted of 3 sections. These two pilots were made of polexy glass. The first pilot, or horizontal flow

possessed a 6.5 meter length, with the length of

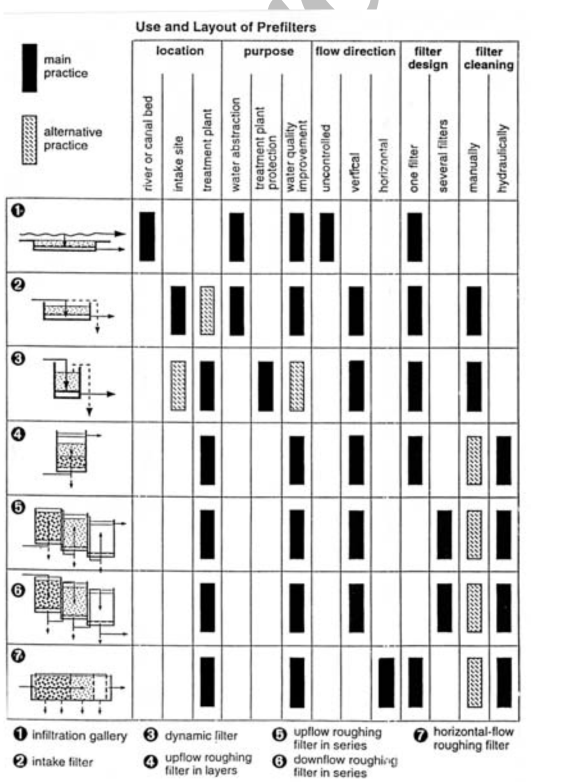
being 3 meters and the size of granules being 12-18 mm. The length of the second portion was 2 m and granules sizes were 8-12 mm, while the length of the third portion was 1m and granule sizes were 4-8mm. Second pilot or down flow roughing filter had 3 m altitude (height), with the first column being 1 m in height and granule sizes of 12-18 mm and second column being 1 mm in height and granule sizes of 8-12 mm and the 3rd column with a 1 m height, with granule sized of 4-8 mm. Each filter had 6 sampling valves which were located in pre-determined distances from each other.The details of each of the 2 pilots are shown in Figures 1 and 2.

The turbid water is synthesized artificially. A low turbidity of 10 NTU initially applied to both pilots which due to the fact that a highly turbid waters were first injected to both systems swiftly blocking the filter and intensifying the need for filter cleaning. Therefore, low turbidities were initially applied, while gradually intensifying turbidity. In horizontal flow roughing filter capable of receipt of highly turbid waters turbicity was

Table1. **Characteristics of pre-treatment processes**

Process		Application
Long-term Store		It only removes sediments ; there is a potential threat of growing algae; efficiency rate for removal of suspended materials in it ;is n50 to 70 percent
Waste Collection Application		Rubbish such as stones ,woods ,etc, Which block or damage the equipment shall be removed and separated.
Preliminary Sedimentation		Only mineral particles; large than 20 microns, are removed; and it is efficiency for removal of suspended particles is 30 to50 percent
Sedimentalation and Flocculation		It needs a coagulant in regard to qualitative modifications of sensitive waters, efficiency of suspended particles removal is 90 to 98 percent.
	Floatation	Needs a coagulant , and dissolved air stream and it is sensitive toward qualitative modification; efficiency for removal of suspended particles in is 90 to 98 percent
	Microstrines	Intruding minute particles; similar to algae , which can be separated solids from water
Pre-filtration	**Dynamic filter**	For removal or decreasing the heavy load of suspended solids form water
	Water filter or water basin filter	For removal or decreasing the load of suspended solids and maintenance of treatment plant.
	Roughing filter	For removal of a high concentration of suspended solids, and loads of organic chemicals and microorganisms from water

Table 2. **Use and layout of prefilters**



escalated up to 350 NTU and 3 different speeds of filterations were applied, in such manner that in the turbidities below 100 NTU, the filteration speed was 1.5 m per hour and with filteration speed of 1 m per hour for range of turbidities from 100 to 300 NTU, while the filteration speed for turbidities of 300 NTU, upwards was 0.5m per hour. In down flow roughing filters, the initial turbidity was set at 10 NTU and the final turbidity was set at 180 NTU with two different filteration velocities of respectively, 1 and 0.5 m/h. Both filters ware applied in a weight oriented manner and because an other goal of this research was to determine the efficiency of the 2 said filters, in removal of parasitic eggs from water, therefore the prepared concentrations contained *Ascaris* ,*Fasicola hepatica* and *Trichosephal* eggs in both water samples, which were injected to both systems, being studied within the above stated speed rates.

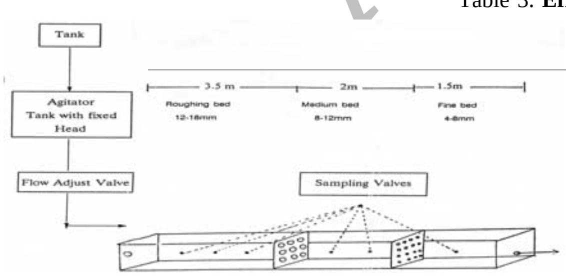


Fig. 1. **Schematic plan of horizontal flow roughing filter**

RESULTS

Following the commissioning of the pilot of two testing periods, in the process of horizontal flow roughing filter, in addition to two testing periods for down flow roughing filters, as in the previous section the initial turbidity was low and it gradually intensified. Both of the turbid samples and samples containing parasitic eggs were synthesized artificially.

The summarized outcomes of both processes in different velocities and granulizations are shown in Table 3. Following the study of the outcomes; it was specified that after accelerating the filteration process, the efficiency of turbidity and parasitic egg removals declined in both filters. The outcomes manifested that fine and coarse particles had a higher efficiency in removal of suspended solids and since the efficiency of removals in horizontal flow roughing filters is directly related to the length of the filter, therefore the further the length of the filter, the longer the contact time interval and hence, the removal efficiency shall be promoted. In regard to down flow rough ingfilters, it can be said that the efficiency for removals, intensifies with height increases which is again due to the long period of the contacts between suspended solids and other pollutants buith granule like beds. Therefore, for highly turbid water filteration speed shall decrease or the duration of contacts shall increase. In horizontal flow filters extension of filters length and in vertical flow filters height increase (up to maximum recommended extent) are possible. Horizontal flow roughing filters have higher efficiency in removal of high turbidities, compared to vertical flow roughing filters, in such manner that horizontal flow filters are applied for removal of high turbidities compared to vertical flow roughing filters, insuch manner that horizontal flow filters are applied for treatments of waters with high turbidity from 500 to 1000 NTU, while, vertical flow filters are not able to receive waters with turbidities higher than 150 NTU. One of the other outcomes of this study, was that there have been equal turbidity levels in both pilots and the surface load or filteration speed has been varied in different time intervals and the removal efficiency in different speeds of 1.5, 1 and 0.5 m per hour have been studied reaching the conclusion that in fixed turbidity, the higher the filtration velocity, the lower the efficiency of removals and vice versa. Obviously, this issue presented based upon Ives Model is predictable, because in this model efficiency of the transformation mechanism is receiprocally related to the speed of the current and the size of sand granules in filter bed. Therefore, it can be concluded in general that the smaller the size of sand granules, the higher the efficiency. One of the other goals of this research is to study the efficiency of filters in removal of parasitic eggs from water, therefore samples polluted by *Ascaris, Fasicola hepatica* and *Trichosephal* parasitic eggs were prepard and injected to both pilots. The outcomes show that in both pilots, efficiency of removal of *Fasicola hepatica* eggs, with 150 micron sized granules, was nearly 93 percent and the efficiency of removal of this parasitic egg was due to the sized of granules. *Fasicola* egg,due to it's large size was trapped in the short route among the pores of bedding granules. However, there is a possibility of *Ascaris* and *Trichosephal* eggs escaping from the pores. Table 3, 4 and 5 and Figures 3, 4 and 5 show the outcomes of this study.

Fig. 2. **Schematic plan of down flow roughing filter**

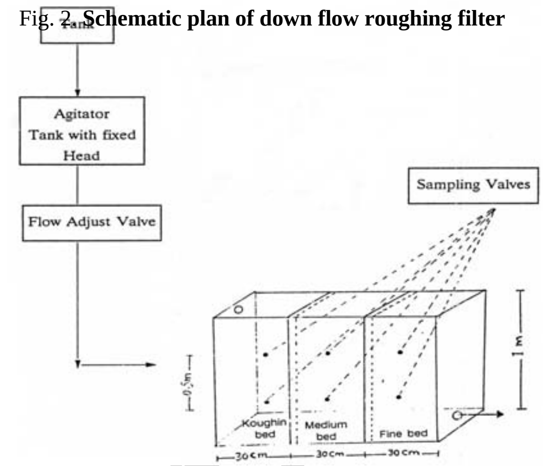


Table 3. **Efficiency of horizontal flow roughing filter and down flow roughing filter in removal of turbidity in various filtration (input turbidity: 150 NTU)**

Filteration velocity (m/h)	Turbidity velocity (%)	
	HRF[1]	DRF[2]
0.5	99.81	98.77
1	99.20	94.70

1.5	93.66	N.A.

[1] HRF: Horizontal Flow Roughing Filter
[2] DRF: Down flow Roughing Filter

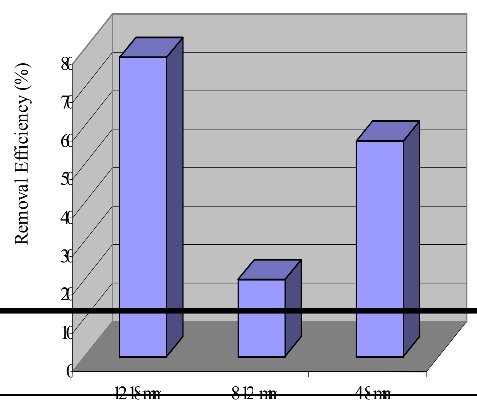
Table 4. **Efficiency of HRF and DRF in removal of parasite egg (*Ascaris* and *Tricocephall*) in various filtration velocity (concentration of effluent parasitic egg)**

Filteration velocity (m/h)

Table 5. **Efficiency of HRF and DRF in removal of parasite egg (*Fassiolla hepatica*) in various filtration velocity(concentration of effluent parasitic egg)**

Filteration velocity (m/h)	Parasite egg removal(%)	
	HRF	DRF
0.5	94.2	91.3
1	90.1	88.4
1.5	84.5	82.1

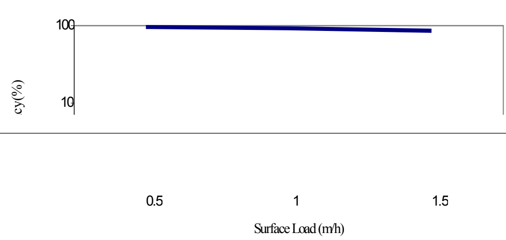
Fig. 3. **Influent of granular particles in turbidity removal of water**



Turbidity velocity (%)

RF	DRF
.3	48.2
.6	44.1
.1	34.7

Fig. 4. **Surface load effect on filteration velocity on turbidity reremoval (input turbidity: 200 NTU)**



DISCUSSION

Following pilot's commissioning, two testing periods in horizontal flow roughing filters and two testing periods for down flow roughing filters were completed. Outcome manifests that coarse media filteration processes are appropriate methods for pre-treatment of highly turbid water. The said filters are able to attain water qualities up to the accepted standards for inlets to slow sand filters. The outcomes of this study show that horizontal flow roughing filters have higher efficiencies in removal of parasitic eggs compared to down flow coarse media roughing filters.

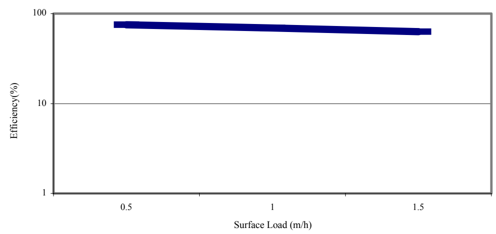
On the other hand, the efficiency for removal of turbidity in roughing filters is higher than the efficiency of removal of parasitic eggs. Following the study of outcomes of tests, it was shown that in fixed concentrations of suspended particles and parasitic eggs, the higher the filteration velocities, the lower the output and rate of removals. It shall therefore, be concluded that the smaller the surface loads and granule sizes, for this bedding, the better the efficiency of both systems for removals. Therefore, it is recommended that homogenous bed, with fine granules, should be applied in coarse particled filteration processes (instead of applying three layered beds, single layer bed were applied).

It was specified during the exploitation period, that the efficiency of both systems is in removal of parasitic eggs with low diameters and only this efficiency should be promoted if the system is blocked, because in the case of filter blockage the inter granule pores would be tighter and the removal rate shall enhance.

Briefly, it can be said that the tests outcomes manifest lower efficiencies, with higher filteration velocities. Additionally, in usual filteration velocities, for roughing filters, finer sized media filters have higher efficiencies.The efficiency of coarse media filteration process with a horizontal flow, is much higher than the coarse media down flow filteration process.

The removal efficiency of suspended particles, by horizontal flow roughing filters has been, at it's best one meter per hour 99.2% and it has been 94.7% in down flow roughing filters. The efficiency of the first filter (HRF) in removal of parasitic

Fig. 5. **Surface load effect on parasitic egg removal (parasitic egg concentration of effluent)**



such as "V" shaped waters overheads and caliberated rulers. Therefore, roughing and slow sand filters, enjoy utmost applications in local resources for water treatment and there is an utmost need for local aids and minimum needs and dependence upon cooperations, other than local cooperations. By applying this treatment method; one can attain and fulfill a treatment method, with minimum costs, in order to gain access to water flows, with appropriate quality for drinking and other cases of consumptions.

Recommendations

With regard to water crises in Iran and throughout the world, a decline in rainfalls, and declining domestic water resources in the recent years and a potential drought threat throughout numerous regions of the country and considering the point that the majority of easily accessed water resources are surface water resources, with low physical and bacterial qualities and are rejected by consumers, necessary actions must be taken to treat these water resources, by applying self reliant processes, which are economic innature. The mentioned processes, such as slow sand filteration and roughing filteration, which decrease national costs, must be studied and completed to provide healthy refreshing drinking water, for consumers.

Some of the issues, that can be pursued in forthcoming research are as follows:

1. A preliminary sedimentation process must be completed, initially for raw effluents, in order to extend the operational duration, and to prevent instant blockage of roughing filters.
2. Research must be carried out upon avariety of particles, that can be applied as granules for coarse media filter beds.
3. Terms of application of coarse media filter smust be studies for artificial feediag of underground water resources.
4. The necessity of designation of a national project for qualitative maintenance of contry's water resources and to determine the safe guarded regions, in the vicinity of water resources, in order to decrease treatment expenses, as much as 16. possible.
5. Research for self reliant processes and economic analyses of the processes.
6. Collection of permitted qualitative and quantitative international standard, for treated and dischargable effluents and wastewaters in surface water resources.

The samples of turbid water were made artificially and water was injected into two systems with the various turbidities. Since one of the other research aims was to investigat efficiency of this filters in removal of parasitic egg from water.

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