Performance of a Direct Horizontal Roughing Filtration (DHRF) System in Treatment of Highly Turbid Water

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ABSTRACT

Vertical or horizontal flow gravel beds can be used in water treatment as roughing filters. In order to improve the performance of horizontal flow roughing filtration (HRF) this process has been modified earlier by applying a constant coagulant dose prior to filtration named direct horizontal roughing filtration (DHRF). In this research a lab scale DHRF pilot plant was used for investigate DHRF performance. The study results indicated that DHRF (6.5 m long consisting of 2.5 m first compartment with 12-18 mm diameter grain, 2 m/s compartment with 8-12 mm diameter and 1.5m third compartment with 4-8 mm diameter) was systematically yielded good effluent quality (<2NTU, C.I=0.95) with raw water quality of 200-400 NTU. DHRF is a versatile pretreatment process capable of handling wide fluctuation in raw water turbidity (200-400 NTU) while operating condition such as coagulant dose [2mg Fe (III)/L], mixing intensity, time and filtration rate remained unchangeable.

Keywords: *Direct horizontal roughing filter, Treatment, Highly turbid water*

INTRODUCTION

The demand for safe water is increasing drastically in the urbanizing areas of the developing countries. Many tropical rivers show a wide fluctuation in suspended solids content and other water quality characteristics; water treatment plants drawing raw water from such rivers are facing growing problems in providing desired treated water quality as well as quantity. This problem is compounded for the towns and small cities in developing countries due to their limited financial resources (Wegelin and Schertenleib, 1993).
The horizontal – flow roughing filter (HRF) is claimed to have the advantage of being able to tackle relatively high raw water turbidity, whilst at the same time offering long filter run time and a simple technology (Galvis et al, 1993). Its applicability is, however, limited, e.g. due to its low filtration rate and limited capability to remove stable colloids and color. In order to improve the HRF performance a modified configuration (DHRF), which combines it with other water treatment, process (es) can be considered. DHRF can overcome the limitation of HRF and on the other hand retain its advantages, notably long run time and ease in operation and maintenance, would be advantages (Pardon, 1992).

MATERIALS AND METHODS

Laboratory scale pilot plant was operated, which consisted of a raw water preparation system, a coagulant dosing system and a

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roughing filter unit. Tap water was fed continuously to the constant head water tank, from there water was passed though a flow meter into the clay mixing tank where it was mixed with clay slurry continuously added by a peristaltic pump. The required clay slurry was prepared every two days. The stack slurry was kept under continuous and vigorous mixing with two constant speed mechanical stirrers was used in the clay-mixing tank.

The turbid suspension was passed to a plain sedimentation tank (l h detention time) to eliminate coarse particles. The required amount of Fe (III) was pumped to the rapid mixing unit and mixed by the same type with the clay suspension. The coagulant suspension was then passed on to the roughing filter unit. The container of the filter bed was made of Plexiglas with 6 m length, 10 cm width and 10 cm height and had 3 compartments. The length and grain size of 1st, 2nd and 3rd compartment were 2.5, 2, 1.5 m, 12-18, 8-12 and 4-8 respectively. Turbidity as the main indicator of the removal performance was expressed in NTU (APHA, 1998). After reaching to head loss around 20 cm, filter cleaning through hydraulic flushing was started.

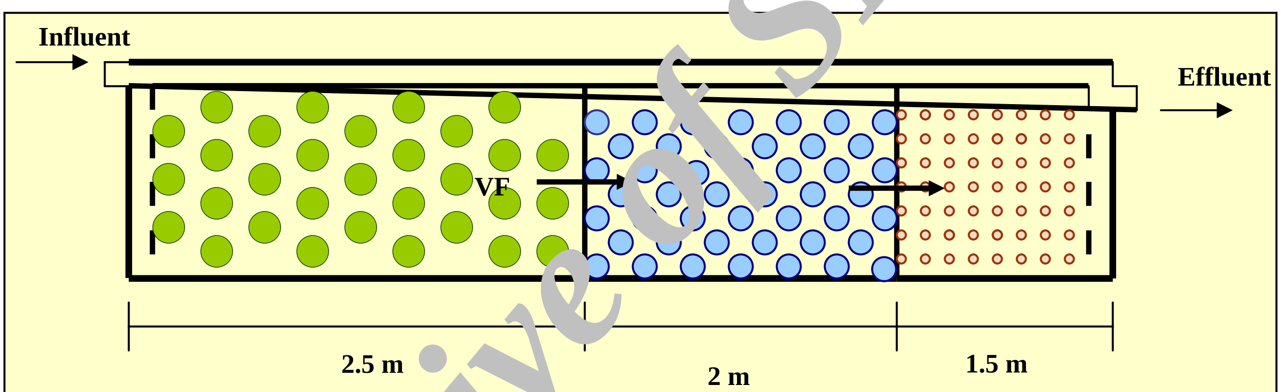

Fig. 1: The schematic of the pilot

RESULTS

The effluent turbidity from DHRF was < 2 NTU (C.I=0.95) via raw water quality of 200-400 NTU and surface rate 1.5-5m/h. (Fig.2).

The effluent turbidity of the filter run with the influent turbidity varying over time was compared with that of 2 filter runs, the first with 200-250 NTU and second with 350-400 NTU. All the parameters remained identical. Effluent turbidity fluctuation in the filter run with the variable influent turbidity remained limited (<± 0.3 NTU) despite the drastic influent turbidity change. In filtration rate 1.5-5 m/h at high influent turbidity (200-250 NTU) and under identical process conditions the average effluent turbidity was from 1.5 ± 0.2 to 1.7 ± 0.2. Also in turbidity 300-350 NTU the average effluent turbidity was from 1.6 ± 0.3 to 1.7 ± 0.3 NTU. The results of the experiments with different Fe (III) dose are summarized in Table 1.At coagulant dose of less than 1 mg Fe (III)/L the effluent turbidity was good to excellent. With dose of ≥ 4 mg (III)/L the turbidity was very low (0.2-0.3 NTU), however, filter run time decreased (< 10.4 h). At 2 mg Fe (III)/l dose the effluent turbidity was low (1.9 ± 0.2 NTU) and the filter run time increased (96h).

The filter run time generally decreased with increasing coagulant dose. Head loss in all cases developed linearly and was within a reasonable limit of 20 cm. The filter ripening period decreased with increasing Fe (III) dose (Table 1). Total filter length was 6.5m, initial turbidity was between 250 to 300 NTU, pH was 7.2 ± 0.2 and filtration rate was 5 m/h.

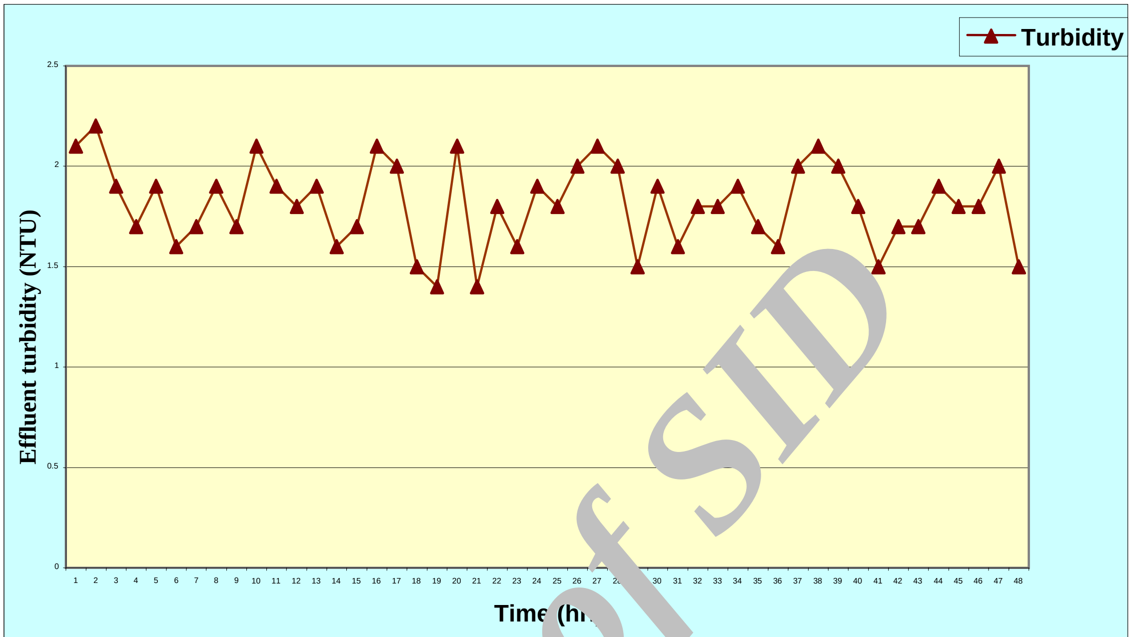

Fig. 2: DHRF performance in treatment of highly turbid water

Table 1: DHRF performance as a function of coagulant dose

Fe (III)dose	Ripening period	Filtration run time	Total head loss	Average effluent turbidity ± sd*
mg Fe	(h)	(h)	(Cm)	(NTU)
1	[illegible]	80	13.9	5.7 ± 1.1
2	4	96	16.7	1.9 ± 0.2
4	2	75	16.1	0.3 ± 0.1
8	1.5	45	10.4	0.2 ± 0.1

* Standard deviation of turbidity between ripening period and filter breakthrough.

DISCUSSION

DHRF is systematically yielded good effluent quality (<2 NTU, C.I = 0.95) with raw water quality of 200-400 NTU it showed to be a versatile pretreatment process in a handling wide fluctuation in raw water turbidity while the process condition remained unchanged (Guibai and Gregrgy, 1991; Aph, 1998).In the case where the operational parameters such as coagulant dose and filtration rate require to remain unchanged for reasons of simple and reliable operation, DHRF will be an effective pretreatment process to produce stable effluent quality even if the raw water quality fluctuates widely or shock loads are received. Therefore less operational control, such as adjust coagulant dose, pH and rapid mixing intensity and time, is necessary in DHRF over a wide range of the raw water quality, turbidity and pH (Ahsan, 1995, Fazeli, 2003, Guibai et al., 1988).

Simple DHRF operation suggests that it could be an appropriate pretreatment technology for towns and small cities in developing countries.

ACKNOWLEDGEMENTS

The authors are most grateful to the laboratory staff of the Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences.

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