THE TREATMENT OF WASTEWATER OF AL-COHOL FACTORY BY FILTRATION AS PRIMARY TREATMENT

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ABSTRACT

The treatment of wastwater of Al-chohol factory was studied using a rapid sand filter column of 0.1 m diameter and 1.35 m long ,as a primary treatment .

The experiment were carried out at different filtration rates (4.5 , 7.5 , and 9) m/h . Sand of effective sizes of (0.4 , 0.6 , 0.8) mm were used as filtering material .

The results of the suspended removal efficiency , total head loss , length of filter run applied obtained from each experiment are compared in order to show how these results change as the filtration variables are varied .

The back wash technique was studied in order to defermine the specific deposit volumn within a filter bed.

***Keywords**: Wastewater, Filtration, Sand filter, Suspended solid removal, Head loss, Back wash*

INTRODUCTION

In water purification the matter to be removed includes suspended silt, collides and micro organisms including algae, bacteria and viruses (AWWA 1971) (Laine 1998).

Filtration processes remove suspended and colloidal particles from water by passing through porous media , the widest use of filtration is in reducing the concentration of solids in potable water supplies (Jaap, 1998).

The most important influent characteristics in filtration process are the suspended solids concentration, particle size, and the distribution of particle size is important because it influences the removal mechanisms that may be operative during the filtration process (Metcal and Eddy, 1970).

Huang and Garcia – Maura (1986) tried to develop a filter performance predication model which takes into consideration influent suspension characteristics. Two experimental parameters reflecting the influent suspension characteristics were incorporated in predicting the progression of filters and rates of head loss development.

The head loss development within a filter bed varies inversely with the size of particles removed from suspension, at least when chemical destabilization is effective (Habibian and O'Melia, 1975).

The choice of filter medium is an important factor and it is dictated by the durability required, the desired degree of purification, and the length of filter run (Kawamur, 1975).

For rapid filter sand is used excursively as filtering material because of its availability, its relative low cost.

The rate of filtration is an important variable in filter operation because it affects the real size of the filters that will be required. High filtration rates tends to carry flock deeper into the bed and require that the flock be strong; if it is not to be sheared and carried out the filter (Steel and McChee ,1984) .

Cleasby and Baumann (1962) tested the filtration of different types of waste water at various filtration rates and stated that one should select the filtration rate that results in a water of acceptable clarity with a maximum overall economy in operation costs.

When a maximum allowable head loss during operation has been obtained or after extended periods of filtration effluent quality has dropped , cleaning of the filter is necessary to restore its capacity and improve the quality of the filter bed water by backwashing process which is effected by the media density size distribution , friability , voidage and water temperature (Fitzpatrick , 1998) .

EXPERIMENTAL WORK

The main instrument in which experiments were carried out as shown in Fig. (1) is the filter column and it accessories , and it consists of the following parts : -

1. The main steel frame , housing the filter column , flow meter , pipes and pumps .
2. supply tanks (for wastewater and back wash water) .
3. manometer tube .

The filter column consists of a perspex column 0.1 m bore , 1.35 m long with inlet and outlet connections so that water may flow either down word (filtration) or up word (back washing) through the column .

The manometer tapping is lying in the upper part of the column 60 mm below the flange and an outlet manometer tapping is in the lower end piece .

The filter bed consists of a sand with the standard effective sizes (Reynold,1982) equal to (0.4 , 0.6 and 0.8) mm with a porosity of (0.442 , 0.47 and 0.502) respectively , the height of filter bed is equal to 0.9 m .

The waste water flows from supplying tank using a rigid plastic pump with 0.2 kw electric motor through a rotameter type having a flow rate capacity ranging from (0.2 – 3) L/min to the top of the filter bed . While the clean water displaces through the effluent outlet at the bottom of the column .

Adjustment of the effluent valve and the valve below the flow meter was done continuously throughout each run in order to maintain constant rate , constant head flow. The time of the filter run and the level of the manometer were recorded . At the same time , samples of the effluent water were collected and the suspended solids of these samples were measured by taking an exact volume of sample and put it in a furnace at (103-105)C for (3-4)h .The total suspended solid was calculated by:

$$T.S.S = (\Delta W/V)*10^6 \quad (1)$$

Each run was continued until either negative head or terminal break through bed occurred .

Washing of the clogged bed was accomplished by passing clean water (from one of the supply tanks) upward through the bed at such rate that caused the media to expand . During back washing a heavy concentration of coagulated materials previously filtered from the water began to flow out through the waste pipe , water samples were collected and settled , the suspended solids was also calculated .

When the filter had been well cleaned , the wash water valve was closed and filter grains were allowed to settle again to their preliminary level and the filter was ready for carrying out another run .

RESULTS AND DISCUSSION

Effect of filtration rate on solid removal efficiency

From results listed in Table (1) and shown in Fig. (2,3,4) it can be seen that the suspended solid concentration in the effluent water increases with increasing flow rate and hence, decreasing the solid removal efficiency and this is due to that increasing filtration rate means an increase in the hydraulic shear force which tends to push the particulate matter deeply in the filter where ultimately emerges in the effluent , also increasing of flow rate causes an increase in the actual velocity in the pore space which leads to a higher scour effect on the deposited suspended particles .

This expects with the result of Cleasby and Baumann (1962) who concluded that the amount of suspended material that passes through the filter is generally increased by higher filtration rates , this increase in suspended material might be so small , however , as to be significant for given water.

However , the suspended solid concentration increases gradually in flow rates of (4.5 and 6) m/h until the flow of (7.5 and 9) m/h in which the concentration is nearly constant in all sizes of sand used. Hence, the optimum flow rate in which increasing flow cases insignificant effect on the removal of solids is achieved in (7.5 and 9) m/h .

Effect of filtration rate on head loss

It can be noticed from Table (1) and Fig. (5 , 6 , 7) the head loss build – up within the filter bed increases as the filtration rate increases , this can be explained that during filtration the pore space available for the flow of water is reduced due to the settling of impurities removed from water in the poers between filter grains , causing a decrease in the coefficient of permeability and an increase in the resistance to water flow which is reflected in higher head loss build – up .

As filtration rate increases , the rate of accumulation of impurities also increases , causing a rapid reduction in pore space , thus increasing the rate of head loss build – up .

Effect of media size on the solid removal efficiency

As shown in Table (1) and Fig. (8). The suspended solid concentration of the effluent water increases as the size of media increases for all flow rates . This may be explained that the decreasing of filter media size will decrease the pore space in the media , resulting in an increase in the staining action of the filter which is an important mechanism in filtration process.

Effect of media size on head loss build–up

From results shown in Fig. (5, 6, 7) and Table (1) it can be seen that the rate of head loss build – up within the filter bed increases as the media size decreases . This is due to:

1. the rapid cloggin of the small pore space , yielded by the fine filter material , which increases the resistance to water flow rapidly , reflecting in a rapid head – loss development .
2. the use of coarse filter grains will allow particulate matter to penetrate deeply into the filter media , causing uniform distribution of pressure , reducing the rate of the head loss build – up .

Effect of filtration rate and media size on length of filter run

All experiments carried out in this work were terminated when negative heads were observed within the filter beds . Results listed in Table (1) and shown in Fig. (9) show that the length of filter run decreases with the increase in filtration rate and the decrease in the filter media size . These two factors have a great influence on increasing the rate of head loss build - up in the filter bed , causing negative head to occur in shorter filter run .

Correlations

A correlation which represented the process was obtained which relate the percentage removal efficiency of suspended material with the effective media size of sand and the rate of flow.

The equation was a polynomial with variance of 0.9994 and relation coefficient of 0.9997 .

$$\% RSM = a + bv + c * Q + dv^2 + e Q^2 \qquad (2)$$

Back washing

The results of back washing test are tabulated in Table (2) , where the process is done at (9 m/h) flow rate .

In order to calculate the specific deposit depending on experimental results a Kou – ying equation is applied (Kou – ying Hsing 1974).

$$\bar{\sigma} = (Q (C_O - C) / C_s L) t \qquad (3)$$

$$C_s = WS / VS \qquad (4)$$

The specific deposits calculated theoretically depending on head loss data is applied according to Shektman equation . (Sakthivadival , et.al 1972).

$$H / H_o = Cl - (\sqrt{\sigma/\theta})^{-3} \qquad (5)$$

It can be seen from Table (2) that the experimental and theoretical specific deposits at media size of 0.4 mm are greater than those at media size of (0.6 and 0.8) mm . Since the volume of particles removed from the suspended is equal to the volume of particles accumulated as deposit in the pores of the media that means that more accumulation of suspended matter takes place into media size of 0.4 mm. The observation satisfy with the results tabulated in Table (1) in which the higher filtration removal efficiency obtained in the media sand size of 0.4 mm .

On the other hand, the experimental results indicated that the correlation between the experimental value of secific deposit and that calculated from Shektman model was reasonably good as shown in Fig. (10).

CONCLUSIONS

1 - The filtration removal efficiency is generally increased as the filtration rate decreases until the rate of (7 and 9) m/h where the suspended solid is nearly constant . Hence the optimum flow rate is 7 m/h and it is within the standard flow rate .

2 - The rate of head loss build – up within the filter bed is decreased as the filtration rate decreases and the media sand increases .

3 - The length of filter run increased as the filtration rate decreases and the filtrating media size increases .

4 - The depth of floc penetration into the filter bed increases with the increase of filtration rate and media size , thus , greater depth of filter bed is required as coarse media is employed or high filtration rate is applied .

5 - The suspended solid concentration of the effluent water from filter bed increased with increasing the media size , i.e. the uses of media size 0.4 mm better than 0.6 and 0.8 mm but at the same time the head loss build – up within the filter bed of media size 0.8 mm is better than 0.6 and 0.8 mm , hence , the optimum media size is 0.6 mm .

6 - A correlation was tested in which the suspended removal efficiency of filter is a function of the effective size of sand and the filtration rate. These variables have been found of great influence on the performance of filter.

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NOMENCLATURE

T.S.S	total suspended solid ,ppm.
ΔW	difference of weight of sample before and after putting in furnace .
V	volume of sample=50 ml.
RSM	removal of suspended material
ν	size of effective sand
Q	flow rate , m/hr
a	66.077
b	0.0737
c	- 2.84
d	- 0.0001
e	0.1685
g	0.000075
σ	the average specific deposit
C_o	concentration of suspended material in the influent , mg/L

C concentration of suspended material in the effluent , mg/L
t time of filter run , second
C_s sladge concentration , mg/L
WS suspended solids in the back wash waste sample , mg/L
VS settled sludge volume fraction , volume per volume .
L total depth of bed in meter
H head loss during filtration , in centimeters .
H_o head loss at beginning of filtration , in centimeters .
σ specific deposit
θ porosity of clean filter .

Table (1) The solid's concentration, head loss and length of filter run at different filtration rates and effective size of sand

Effective size (mm)	Filtration rate (m/h)	Head loss, Δh (cm)	Length of filtration run, t (h)	Inlet solid concentration C_o (mg/l)	Outlet soid concentration C (mg/l)	Solid removal efficiency , %
0.4	4.5	27	7	120	36	70
	6	40	6	120	38	68
	7.5	78	5	120	38.9	67.5
	9	120	3.5	120	39	67.5
0.6	4.5	20	12	120	43	64.1
	6	37	11	120	45	62.5
	7.5	70	9	120	45.9	61.7
	9	114	6	120	46	61.7
0.8	4.5	16	14	120	60	50
	6	30	12	120	62	48.3
	7.5	61	10	120	62.1	48.25
	9	102	8	120	62.9	47.5

Table (2) The values of theoretical and experimental specific deposit of back washing process

Effective size (mm)	H_o (cm)	H (cm)	W (mg/L)	V	C_s	$\sigma_{exp.}$	$\sigma_{ther.}$
0.4	248	128	4386	0.034	$12.8*10^4$	0.022	0.017
0.6	242	128	4364	0.018	$23*10^4$	0.019	0.0168
0.8	230	128	4345	0.016	$26.8*10^4$	0.017	0.0154

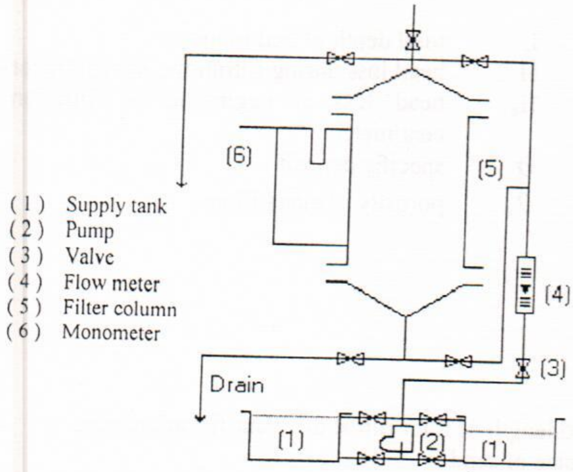

Fig. (1) Filter column

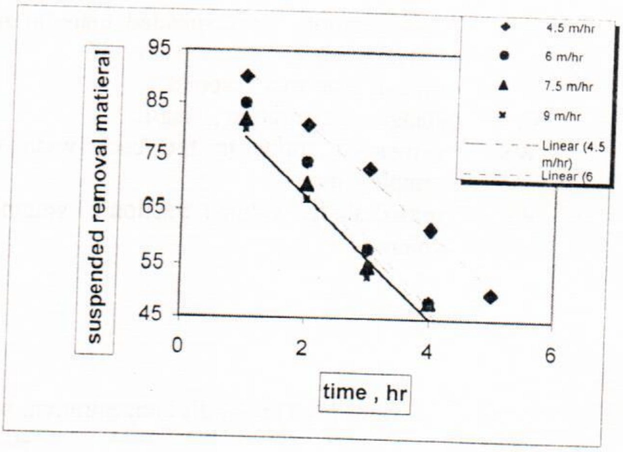

Fig. (4) Fig (4): Variation of suspended material removal efficiency with time for sand effective size 0.8 mm at different flow rates

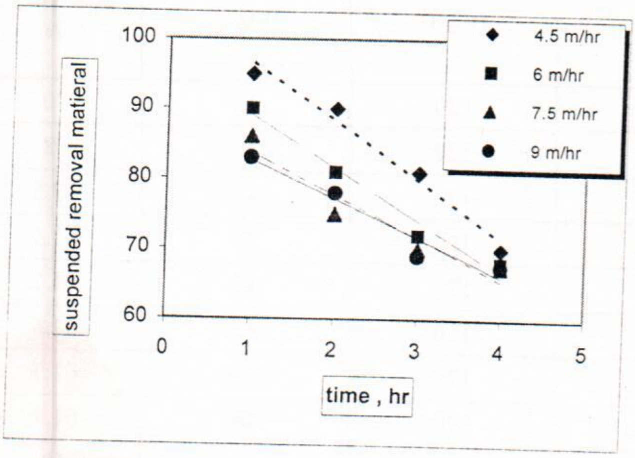

Fig. (2) Variation of suspended material removal efficiency with time for sand effective size 0.4 mm at different flow rates

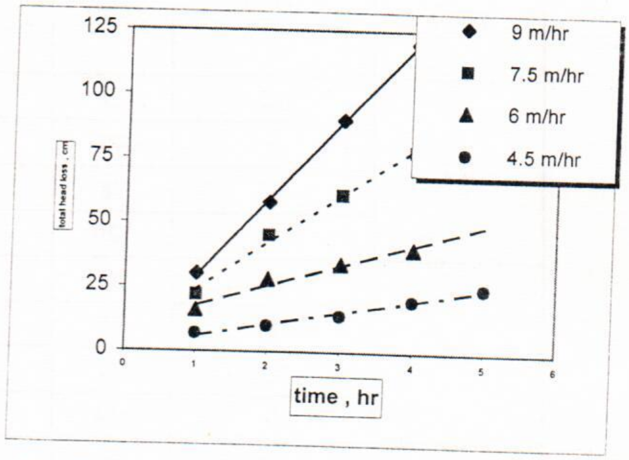

Fig (5) : Effect of filtration rate on head loss build up for sand effective size 0.4 mm at different flow rate

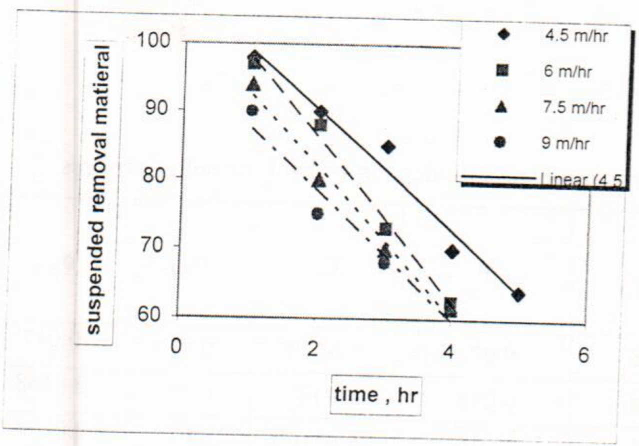

Fig. (3) Variation of suspended material removal efficiency with time for sand effective size 0.6 mm at different flow rates

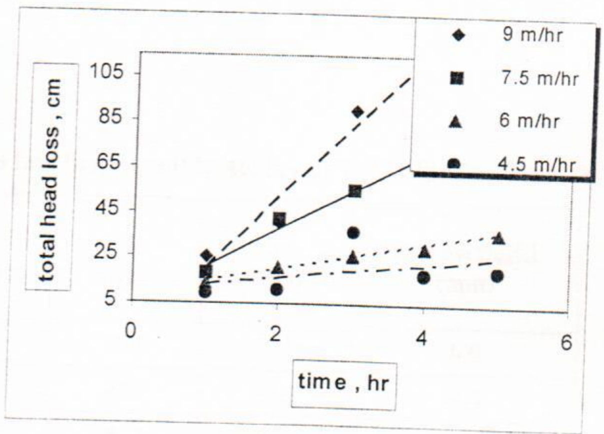

Fig (6): Effect of filtration rate on head loss build up for sand effective size 0.6 mm at different flow rate

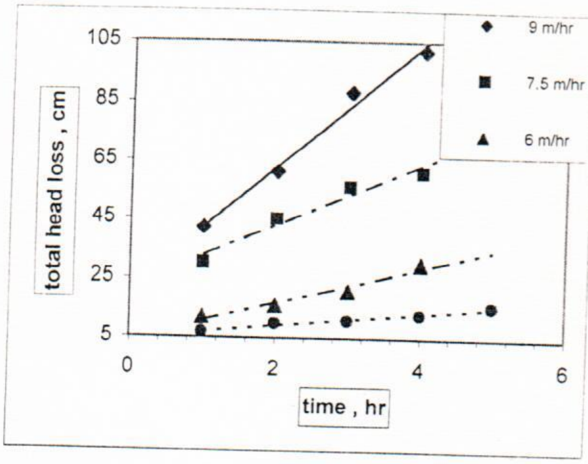

Fig (7): Effect of filtration rate on head loss build up for sand effective size 0.8 mm at different flow rate

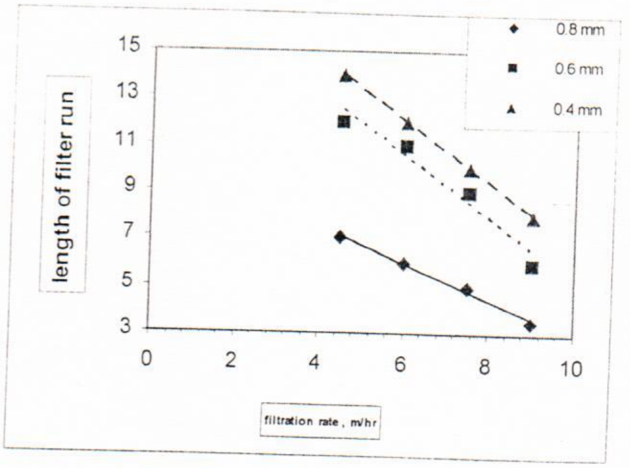

Fig (9): Effective filtration rate on length of filter run at different media size

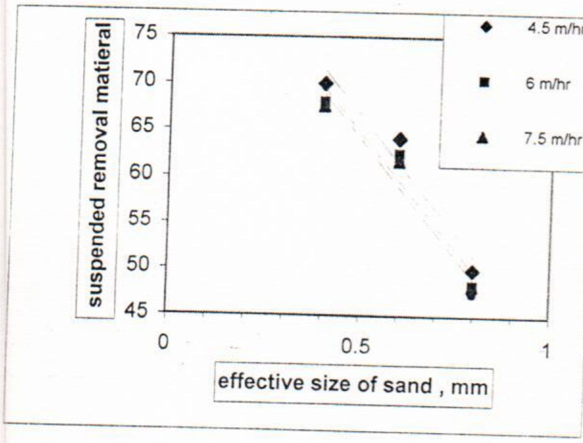

Fig (8): Effective of media size on suspended removal of material efficiency at different flow rates

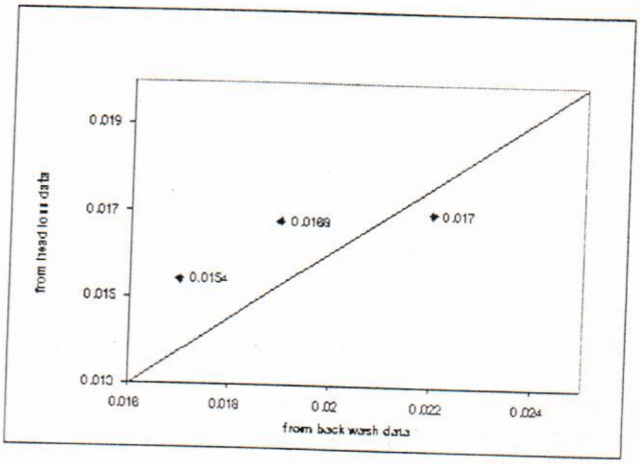

Fig (10): Values of specific deposit from back wash data compared with head loss data