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CHARACTERISTICS OF A DUAL-MEDIA FILTER IN DIRECT FILTRATION PROCESS

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1.INTRODUCTION

During the past 30 years direct filtration has been used all around the world in the water treatment process for water with low turbidity i.e less than 10 mg/l.

The problem for single-medium sand bed filter is that during the summer when the snow melts or during the rainy season the water turbidity increases tremendeously and the filter run is consequently shortened because of the filter clogging and the fast headloss build-up.

To remedy these problems a dual-media filter with coarse medium at the upper part and sand at the lower part has been proposed.

The objective of this study is to show the removal efficiency of the coarse medium.As it has been demonstrated in these experiments,for the same removal efficiency as the sand bed,the coarse medium bed has a very low incremental headloss.

2.EXPERIMENTAL APPARATUS AND METHODS

As shown in Fig.1 the filter consists of a feeding system , two rapid-mixing tanks,a head tank,two 7 cm interior diameter columns A and B and a water manometer board.

In the column B a 90 cm coarse medium bed is housed in the upper part and in the lower parts of both columns an identical sand bed is housed.The sand size is 0.5mm~0.6mm.

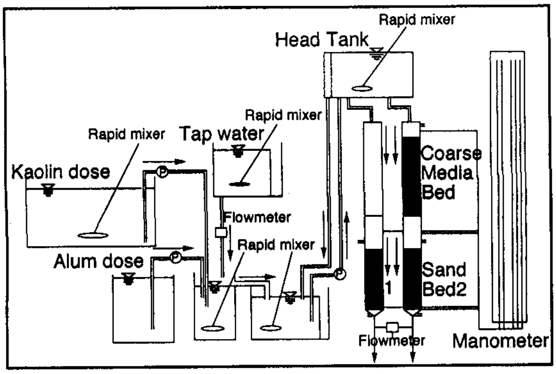

Fig.1:Experimental apparatus

In this experiment,the removal efficiency of two different types of coarse medium,semi-cylindrical (Type A) and cylindrical (Type B),has been investigated.The Coarse Medium is a vinyl tube with 2 mm interior diameter and 4 mm exterior diameter.

The filters have been simultaneously fed by a constant head tank with a kaolin solution.

The filtration experiments were performed at a constant rate and the flow was manually controlled by continuous adjustment of the downstream valve.

The headloss accross the filter was measured by the water manometers during the sampling.The sampling ports and the headloss manometer points are located at the same level.

The different filtration rate were 120 m/day ,240 m/day and 360 m/day.

Alumine Sulfate ($Al_2(SO_4)_3.18H_2O$) has been used as coagulant at ALT ratio of 0.01,0.03 and 0.05 .

The samples were taken every hour during the first 10 hours of the run time and each two hours during the rest of the run time.

The experiment ends when the available headloss of 255 cm is reached or when the water filtrate doesn't meet the standard concentration of 2 mg/l.

Another experiment has been performed in order to evaluate a 25 cm sand bed filter coefficient at different incremental depths with three different sand sizes: 0.5mm~0.6mm ,0.85mm~1.0mm and 1.20mm~1.40mm..

Coagulant has been used at different concentrations:3 mg/L,5 mg/L and 9 mg/L.

The influent concentration has been 20±2 mg/L.

Cleaning of the filter has been done by a backwashing at a flow rate of 8L/min.

3.RESULTS AND DISCUSSION

From Fig. 2 we can see that for the same mass of kaolin removed the type A has a headloss almost twice as much as that of the type B and both types have a very low incremental headloss .During 24 hours run time both types A and B don't reach a total haedloss of 10cm.However,from the Fig3 the type A has a filter coefficient 1.5 to 2 time higher than that of the type B The filter coefficient is the most important criterium because a low turbidity in the sand bed will enhance the filter run time.For this reason,the type A has been chosen.

In the Fig 4,the dual-media filter(coarse medium+sand) has a run time 36 hours whereas

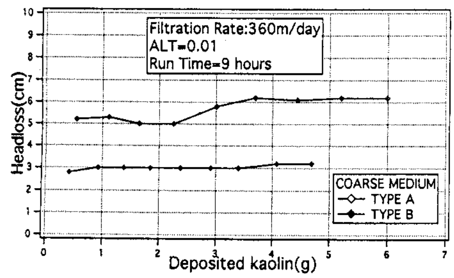

Fig.2:Headloss versus deposited kaolin

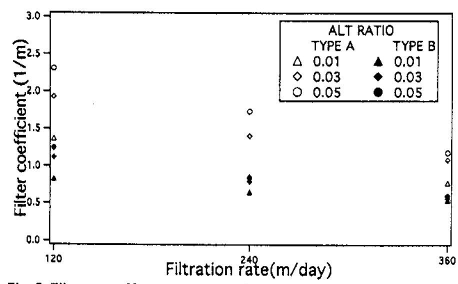

Fig.3:Filter coefficient versus filtration rate for two types of coarse media

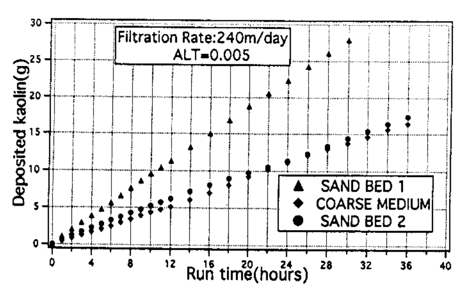

Fig4:Deposited kaolin versus Run time

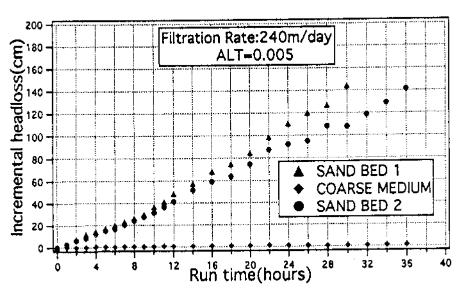

Fig.5:Incremental Headloss versus Run time

the single-medium sand filter has only 30 hours.The use of the coarse medium has lengthened the run time for 6 hours.

The mass of kaolin removed after 36 hours run time is almost the same for the coarse medium and for the sand bed 2.

We can see from Fig 5 that after 30 hours run time the sand bed 1 has an incremental headloss of 144 cm for 27.9 g of kaolin removed,the sand bed 2 has 108 cm for 14.4 g removed and the coarse medium has almost 1 cm for 13.7 g removed.

The filter coefficient for the coarse medium has been calculated from the well-known first-order differential equation proposed by IWASAKI:

$dC/dZ = -\lambda C$

C=turbidity (mg/L)

Z=filter depth (m)

λ=filter coefficient (1/m)

Integrated over the depth it becomes:

$C/Co = \exp(-\lambda Z)$

In the Fig.6 ,the coarse medium filter coefficient has been evaluated at different depths every 3 hours during 24 hours The filter coefficient doesn't depend on the mass of deposited kaolin.

The coarse medium filter coefficient ranges from 0.5 to 2.5 per meter.From the Fig 7 and 8 we can see that the filter coefficient increases with ALT ratio and decrease with filtration rate increase.

The sand bed filter coefficient ranges 2.0 to 18 per meter and depends on the mass of the deposited solid.It increases,reaches to a maximum and then decreases approxima- tely according IVES'equation.

The sand bed filter coefficient is high for the small sand size(Fig.9) and for the low filtration rate (Fig.10).

The sand bed filter coefficient increases with small ALT ratio increment but decreases with high ALT ratio(Fig.11).

We can see from Fig.12 and Fig.13 that the sand bed filter coefficient is higher in the upper parts of the filter.

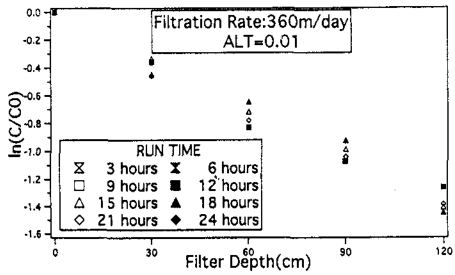

Fig.6:Filter coefficient versus depth

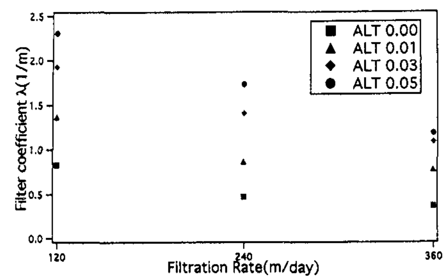

Fig.7:Filter coefficient versus filtration rate

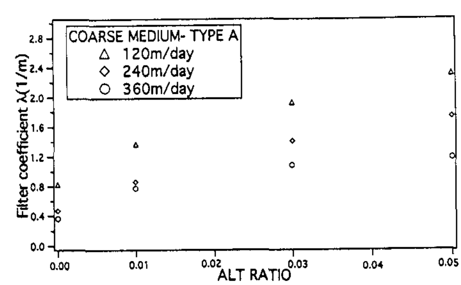

Fig.8:Filter coefficient versus ALT ratio

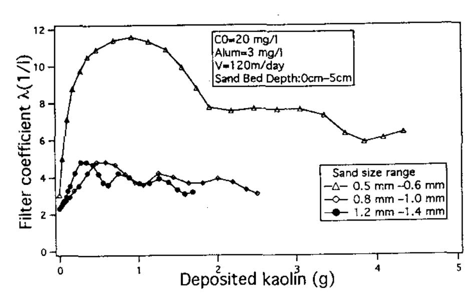

Fig.9:Filter coefficient versus deposited kaolin for different sand sizes

4.CONCLUSIONS

From these experiments some conclusions can be drawn:

1.Both types A and B have a very low headloss but the filter coefficient of type A is 1.5 to 2 times higher than that of the type B.

2.The coarse medium filter coefficient doesn't depend on the mass of deposited kaolin whereas the sand filter coefficient depend on the mass of deposited kaolin .Both media filter coefficients depend on diameters and shapes of the materials, the filtration rate and ALT ratio.

3. The coarse medium filter coefficient increases proportionally with the AL ratio and decreases when the filtration rate increases.

The sand filter coefficient increases,reaches to an optimum then decreases.

4.For the same mass of kaolin deposited,the coarse medium filter headloss is by far fewer than that of the sand.

5.The dual-media filter has proved to perform well and to solve the quick headloss build-up and clogging problems encountered by the single sand medium during the high turbidity influent.

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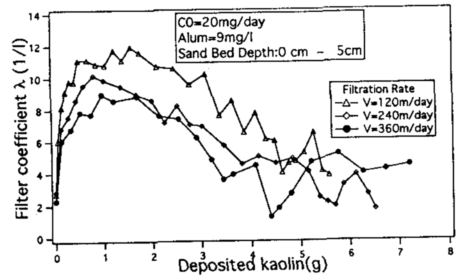

Fig.10:Filter coefficient versus deposited kaolin for different filtration rates

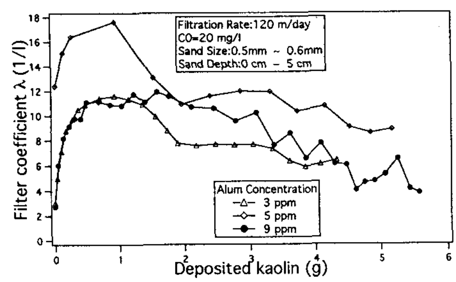

Fig.11:Filter coefficient versus deposited kaolin for different alum concentrations

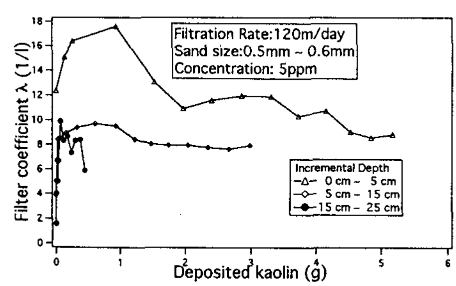

Fig.12:Filter coefficient versus deposited kaolin for different incremental depths

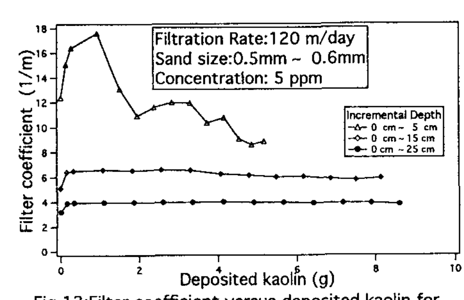

Fig.13:Filter coefficient versus deposited kaolin for different averages incremental depths