

King Saud University
Deanship Of Scientific Research



First National Applied Research Program

Project: DSR-AR-56

**Effect of Mechanical Flocculation on the
Performance of Tertiary Sand Filtration**

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Objective

- To investigate the influence of flocculating settled effluents from biological stage of treatment on the performance of gravity sand filtration for the removal of suspended solids and organic matter

Scope of Work

- Determination of the appropriate flocculation speed and time that can be used for flocculating settled secondary effluents prior to filtration.
- Comparing the performance of a sand filtration system preceded by flocculation with that of a mere filtration.
- Finding the optimum filtration rate and other operational parameters for the mechanical flocculation-filtration system.

Materials and Experimental Methods

- Testing of Filter Sand
 - Sand from Manfuha Wastewater Treatment Plant in Riyadh (used for tertiary filtration)
 - Tested for:
 - Acid solubility
 - Specific gravity
 - Sieve analysis
 - Organic impurities
 - Fine particles (< 75 microns)
 - Porosity of sand medium



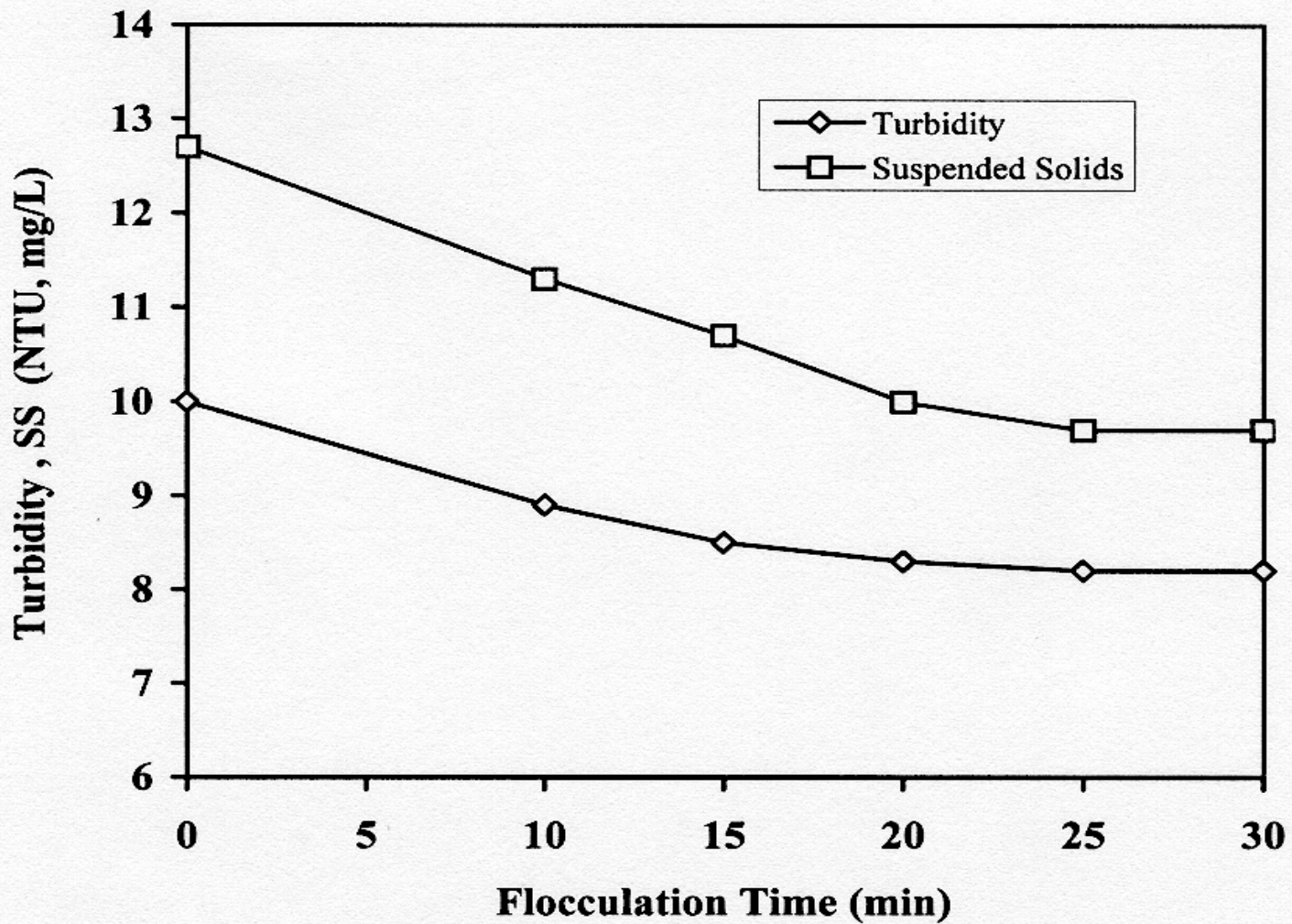
Al-Safaniyah Sand

Results of Tests Conducted on Al-Safaniyah Sand

Test	Sample 1	Sample 2	AWWA Standards (B 100-80)
Sieve analysis			
Effective size (d_{10}), mm	2.5	2.5	-
Uniformity coefficient	1.22	1.23	-
Size range, mm	2.0 – 3.4	2.0 – 3.4	-
Acid solubility	0.2%	0.2%	< 5%
Specific gravity	2.59	2.60	> 2.5
Organic impurities	Lighter than standard	Lighter than standard	Lighter than standard
Fine particles	0.08%	0.09%	< 2%
Porosity of sand medium	39%	39%	-

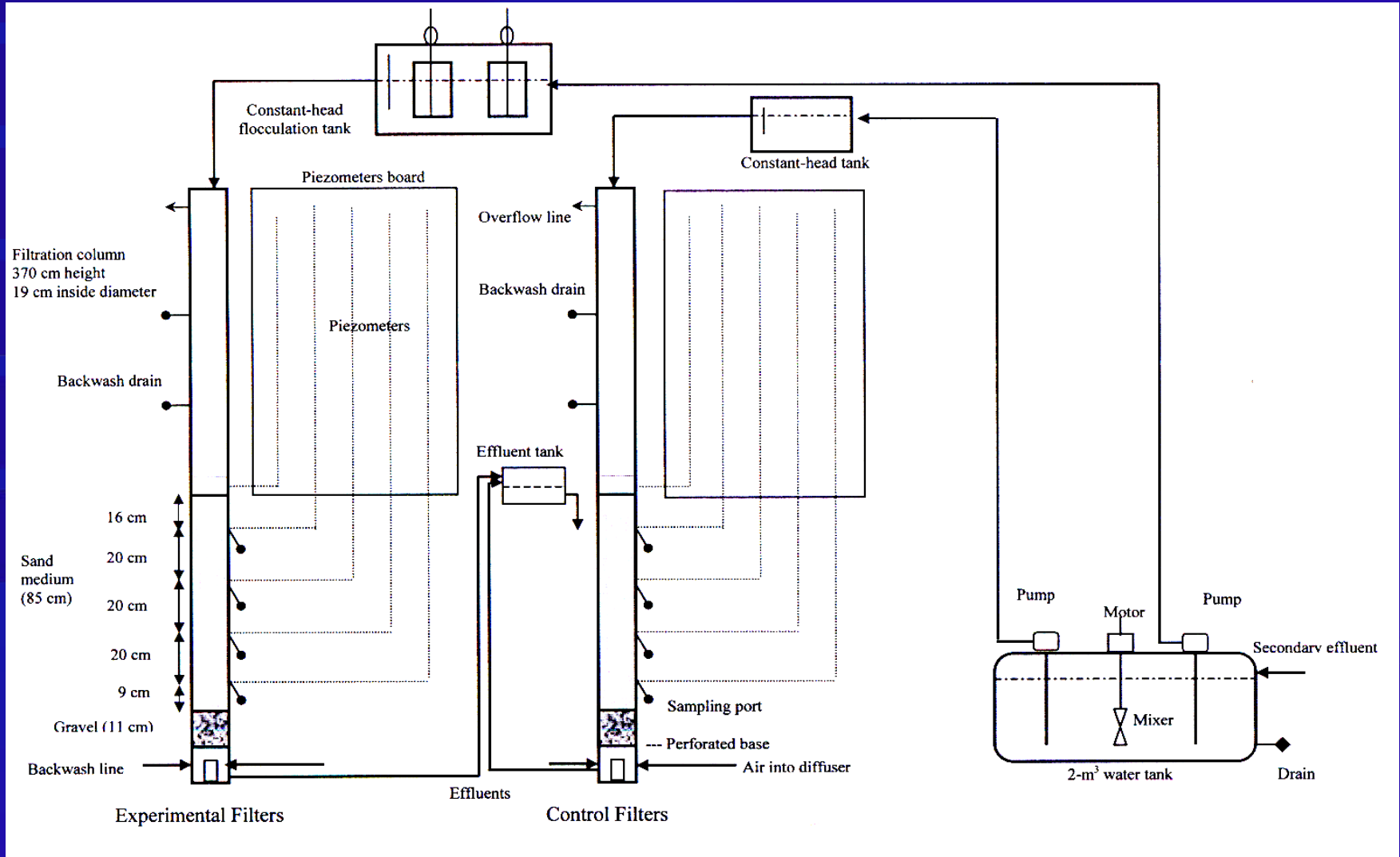
Flocculation Experiments

- Purpose
 - To determine appropriate flocculation speed and time that can be used for flocculating settled secondary effluents prior to filtration.
- Sample
 - Effluent of secondary clarifiers (King Saud Univ. Plant)
 - Three sets of samples on different dates
- Test apparatus
 - Jar Test Apparatus (six 2-L jars)
 - Flocculation times: 10, 15, 20, 25, 30 minutes
 - Parameters measured: SS and Turbidity



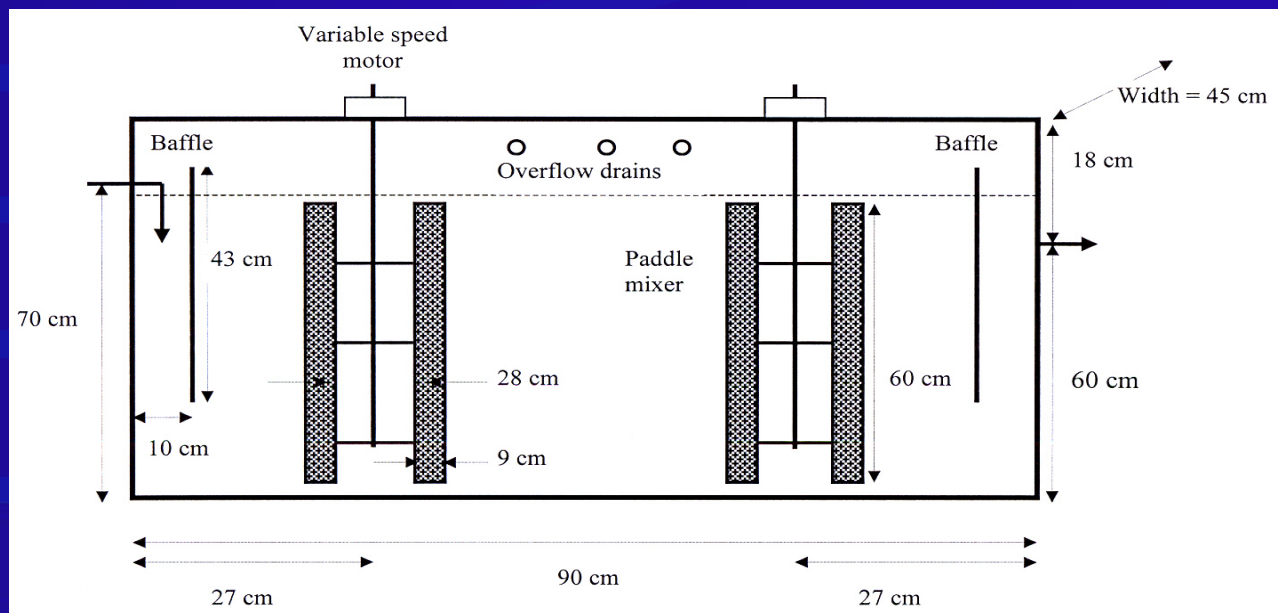
Supernatant turbidity and SS at Different Flocculation Times

Filtration Experiments

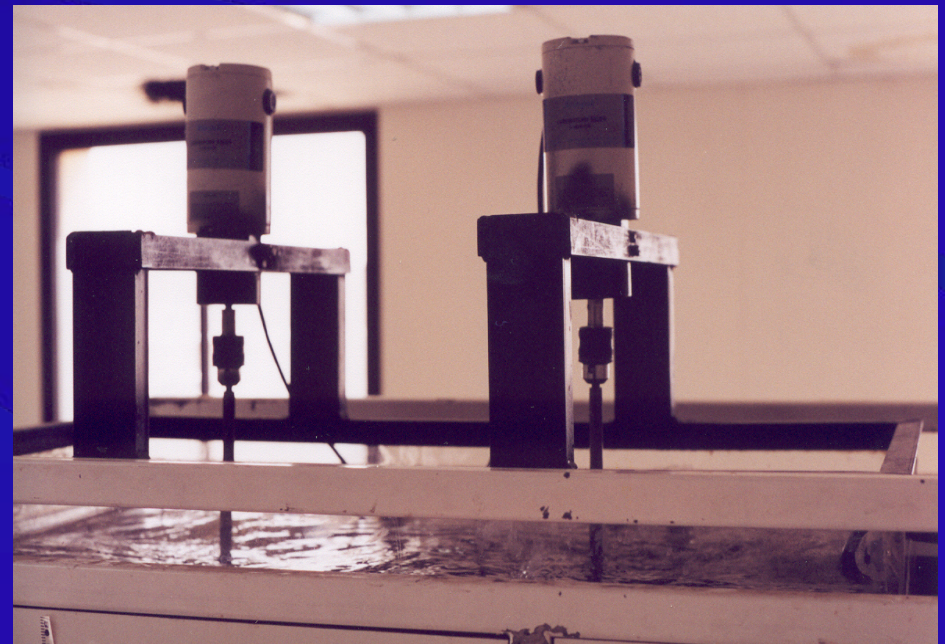
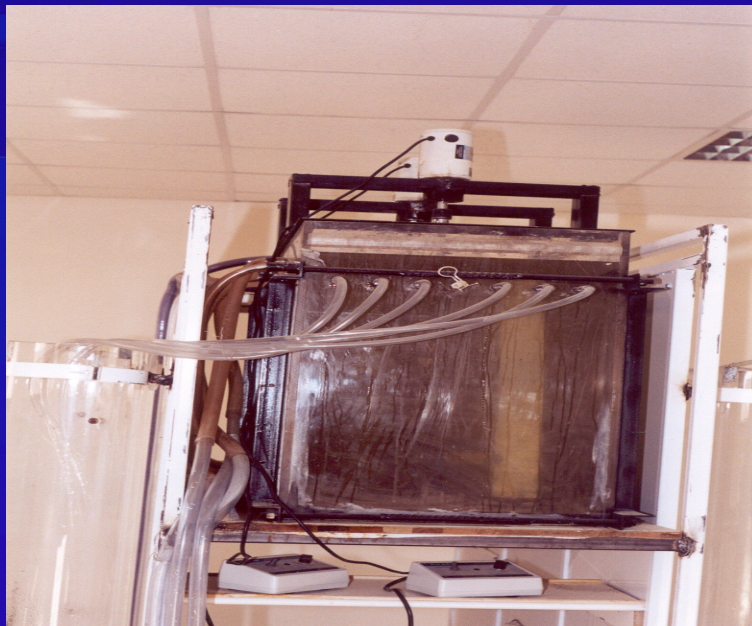


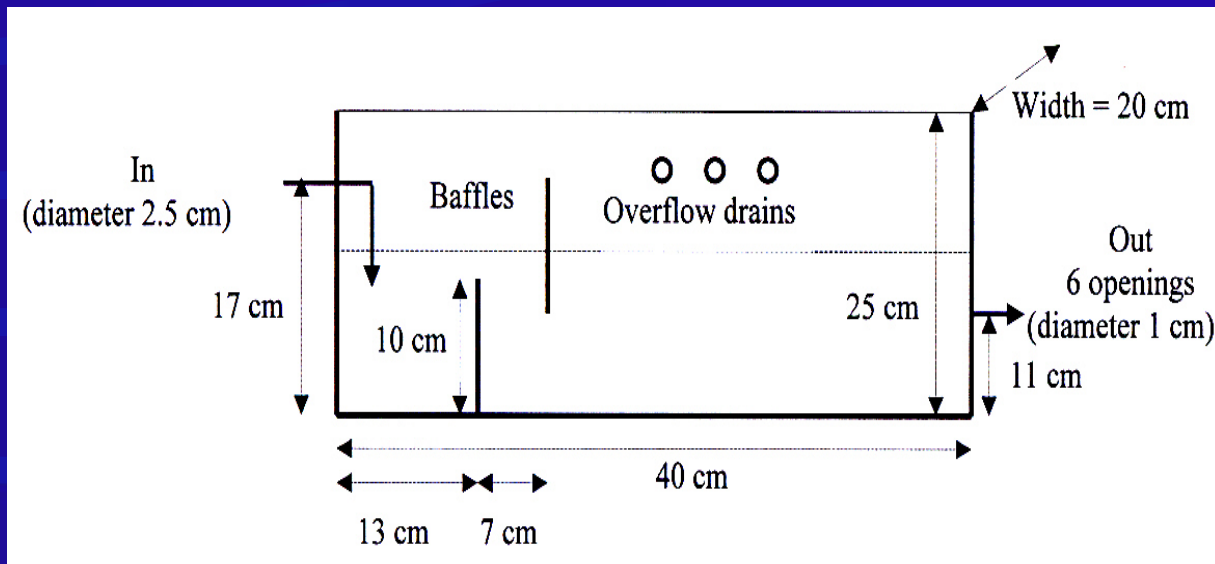
Pilot Filtration System



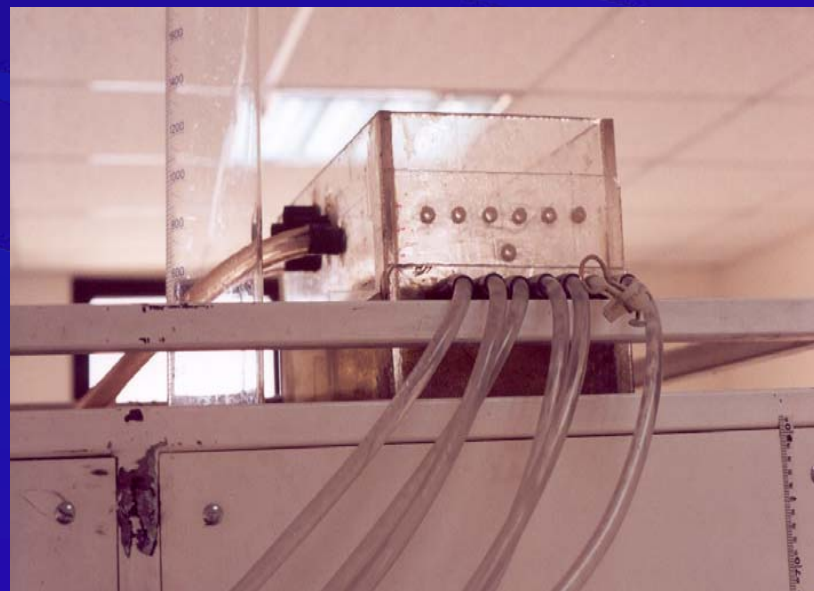


Flocculation Tank





Equalization Tank

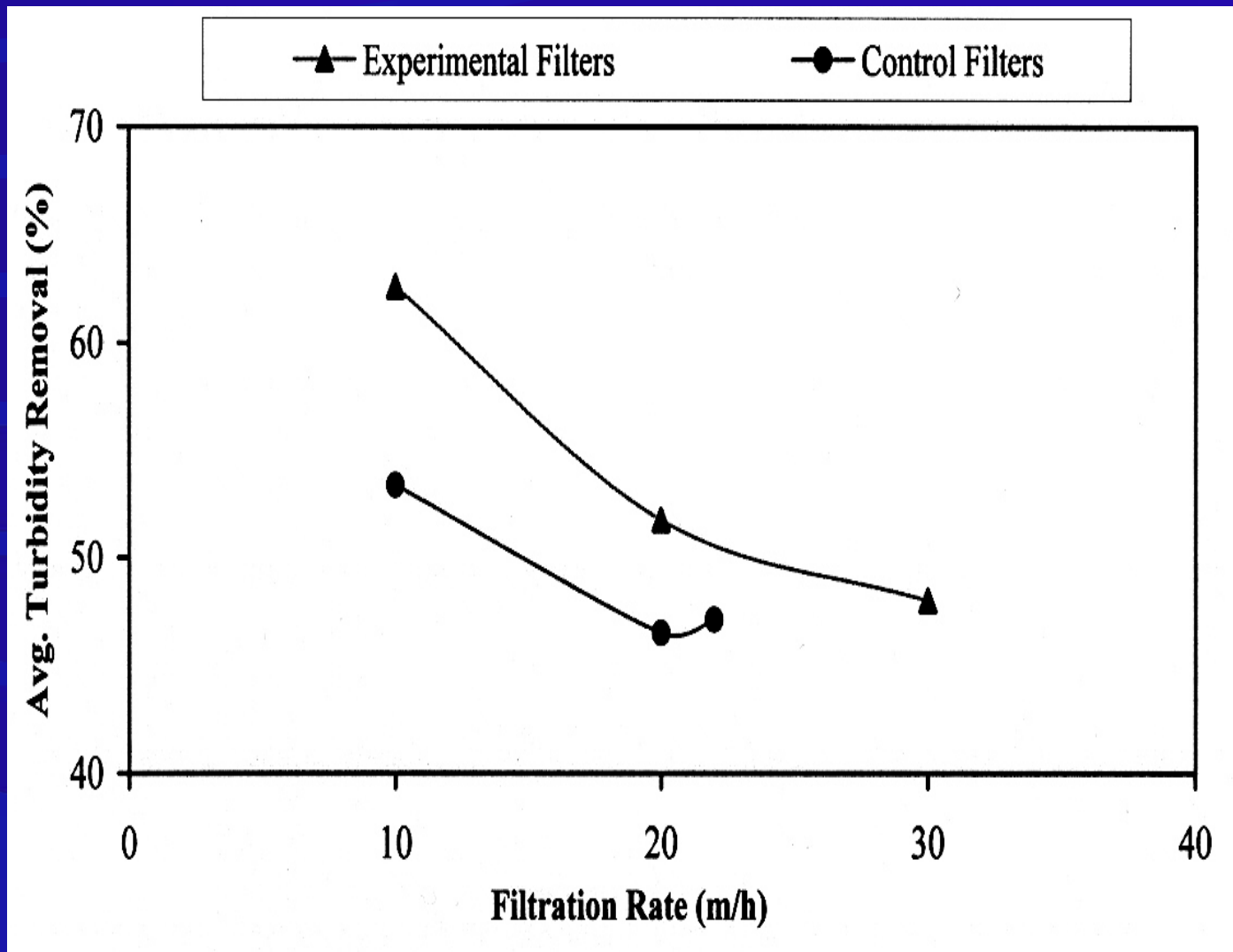


- **Filtration Rates:**

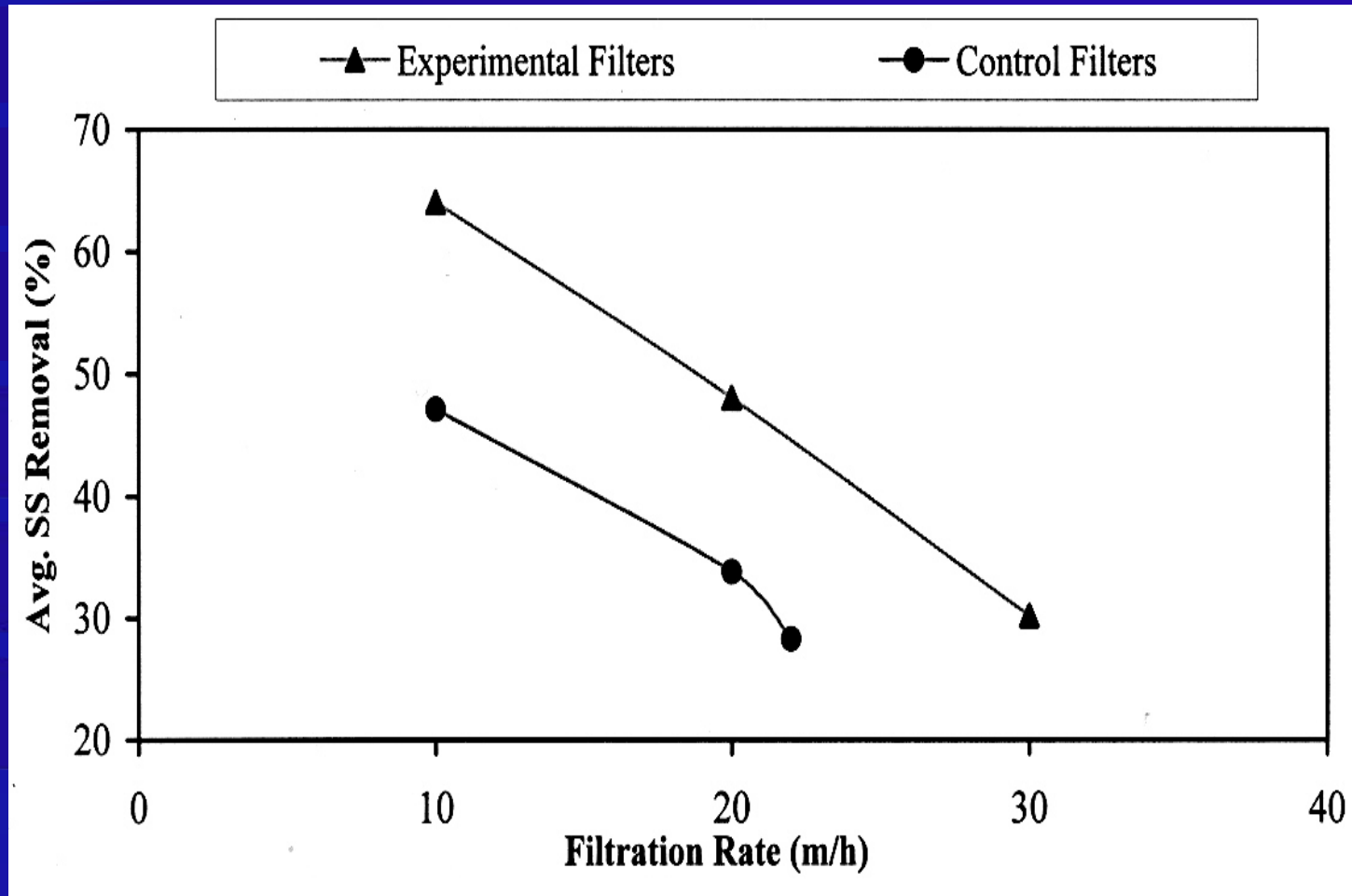
- For Experimental Filters: 10 , 20 , and 30 $\text{m}^3/\text{m}^2.\text{hr}$
 - For Control Filters: 10 , 20 , and 22 $\text{m}^3/\text{m}^2.\text{hr}$

- **Parameters Measured:**

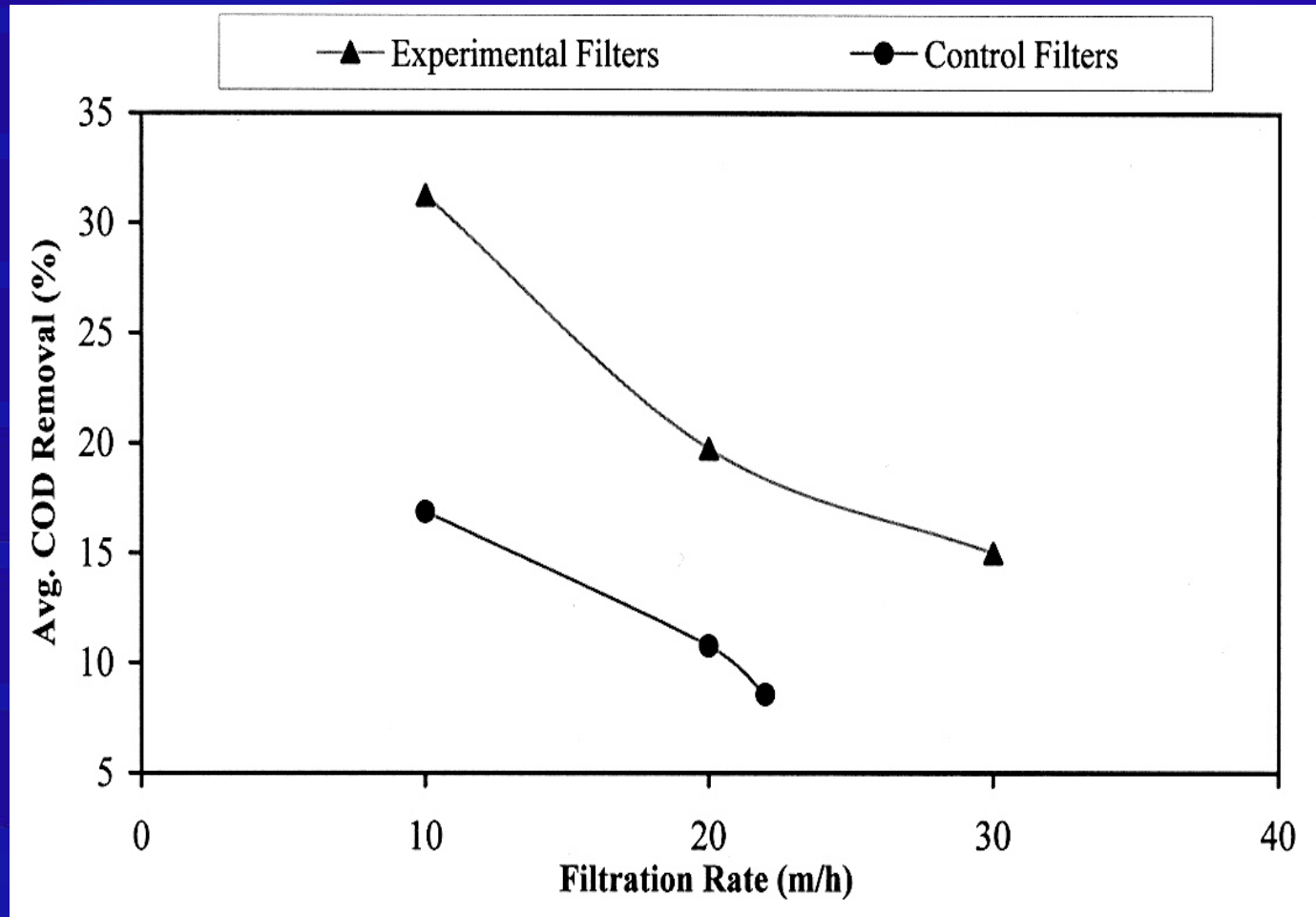
- For Filter Influent and Effluent
 - Turbidity
 - SS
 - COD
 - Fecal Coliform
 - pH
 - Temperature
 - At different Depths along the Sand Column
 - Headloss
 - Filtrate Turbidity



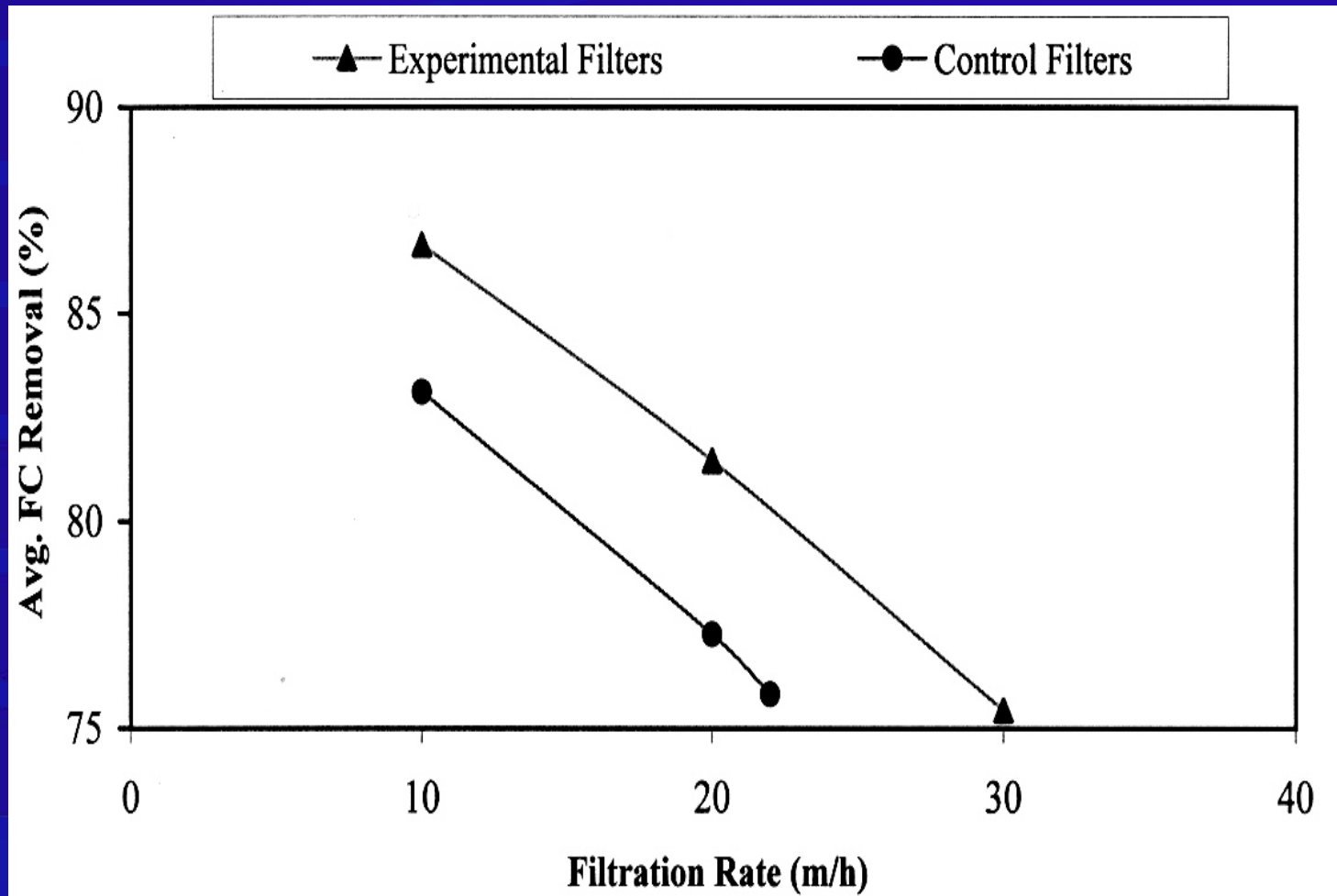
**Performance Comparison Of Experimental and Control Filters
in Terms of Turbidity**



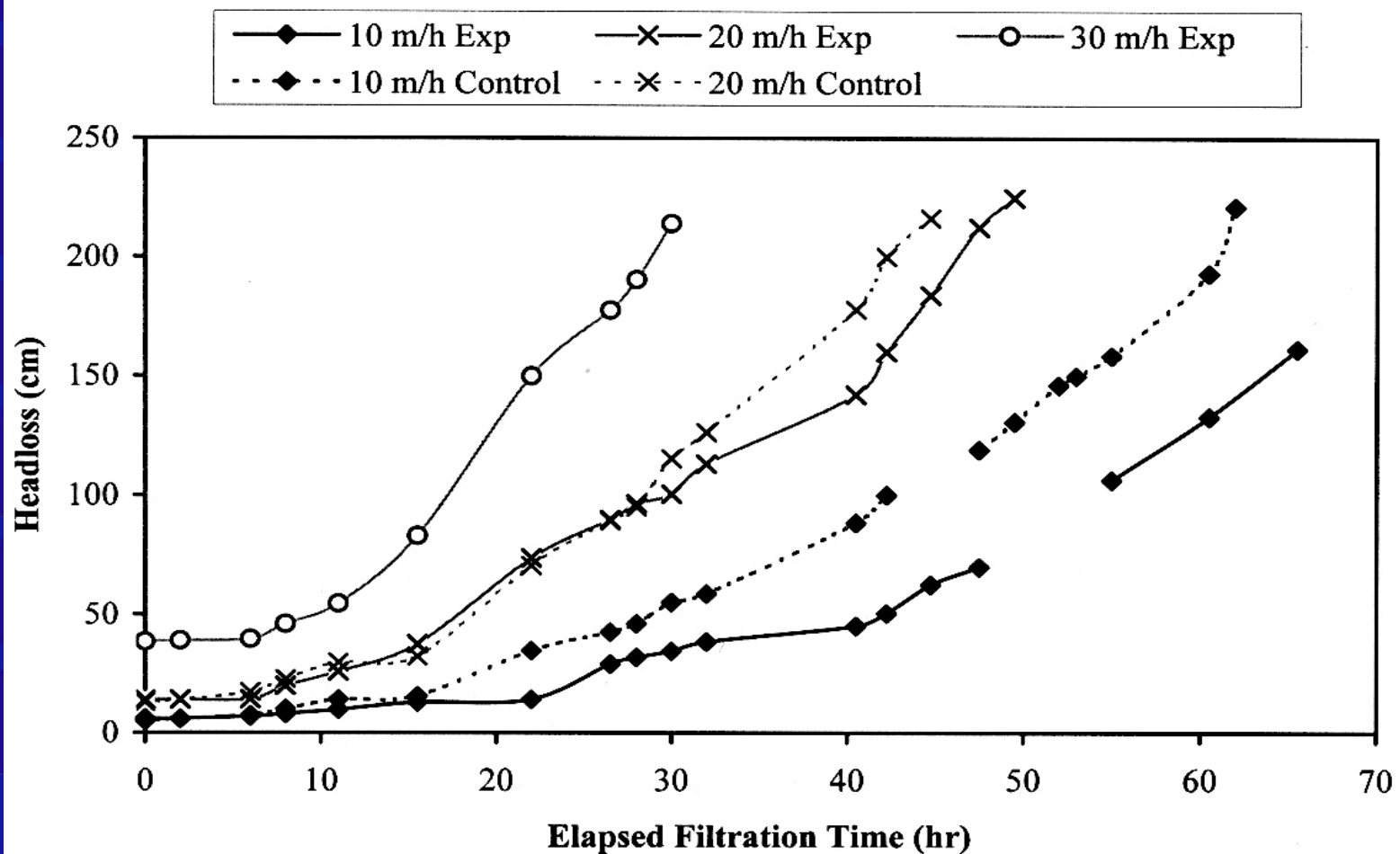
**Performance Comparison Of Experimental and Control Filters
in Terms of SS**



**Performance Comparison Of Experimental and Control Filters
in Terms of COD**



**Performance Comparison Of Experimental and Control Filters
in Terms of Fecal Coliform**



Total Head loss as a Function of Filtration Time For the Experimental and Control Filters



Conclusions

- Flocculation of settled trickling-filter effluent prior to gravity sand-filtration had positively influenced the filter performance
- Due to flocculation, the average removal efficiency, at the filtration at 10 m/h, increased from:
 - 53% to 63% for turbidity
 - 47% to 64% for SS
 - 17% to 31% for COD
 - 83% to 87% for fecal coliform

Conclusions

- At the filtration rate of 20 m/h, the removal increased due to flocculation from
 - 47% to 52% for turbidity
 - 34% to 48% for SS, 11% to 20% for COD
 - 77% to 81% for fecal coliform
- The removal efficiencies for all quality parameters at the rate of 30 m/h were worse than those at lower rates, and the average values were:
 - 48% for turbidity
 - 30% for SS
 - 15% for COD, and 75% for fecal coliform

Conclusions

- The filtration run length also increased due to flocculation, although slightly, from
 - 2.5 days to more than 3 day for the filtration rate of 10 m/h
 - 46 hours to 50 hours for the rate of 20 m/h
 - Filtration of flocculated effluent at the rate of 30 m/h lasted for about 30 hours

Conclusions

- The headloss build up in filters fed with unflocculated effluent was higher than in filters preceded by flocculation
- The effluents quality for both the control and experimental filters satisfied the MOMRA reclaimed-water reuse criteria for unrestricted irrigation in terms of the SS and COD, on the average

Conclusions

- Headloss and turbidity measurements along the filter bed during the course of filtration disclosed that both surface and depth filtration were involved although surface filtration was the predominant mechanism of solids removal during the later stages of filtration