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BOOK OF ABSTRACTS

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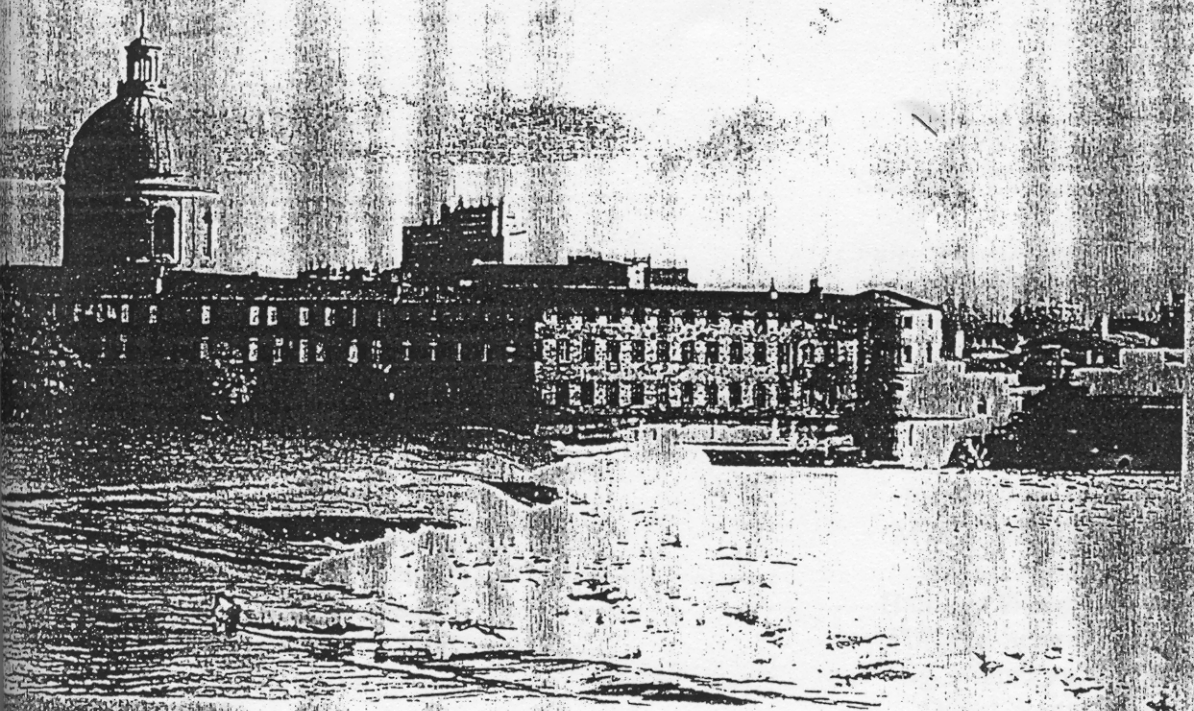

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Influence of water compositions hydrodynamic and conditioning suspensions on flux enhancement in an immersed membrane system and fouling potential

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Abstract

A clarification step was studied using immersed membrane system. The objective was to quantify the importance of operational conditions on the membrane fouling and its dynamics was also evaluated by frontal filtration using the cake filtration model. Aeration had a positive impact to reduce compound accumulation on membrane, it was not sufficient to prevent membrane fouling. In fact only a $FeCl_3$ conditioning favoured the increase of critical flux value, a 100 L/h/m^2 was reached under a 0.5 bar TMP. This permeate flux value was 2-3 times higher than the values obtained without conditioning or with Alum and PACl adding. To minimise $FeCl_3$ added, a very low amount of 10 mg/L $FeCl_3$ could be sufficient to intensify the filtration step because of the high selectivity of the membrane only the coagulation step seemed sufficient and a complete flocculation step was not necessary. This phenomena was also observed when studying clarification of salted water, the adding of $FeCl_3$ with 0.5 gSS/L allowed to reach a critical flux value of 41 L/h/m^2 and 34 L/h/m^2 even if the filtration was operated under a 5 gSS/L of bentonite. In this case the combination of aeration and $FeCl_3$ conditioning allowed to promote some increasing of the permeate flux values about 42 L/h/m^2. The hydraulic resistance values appeared largely to minimise when using $FeCl_3$ conditioning.

Keywords. Suspended solids clarification-Immersed membrane–coagulation–specific hydraulic resistance

INTRODUCTION

Nowadays pressure driven membrane processes are widely applied for producing high water quality whatever the water resource [1,2]. Micro-Ultrafiltration is one of technology developed to clarify water and replace conventional water clarification by providing not only a very good quality of water but also because of removing specific infectious contaminants including *Giardia* or *Cryptosporidium*. It is also strongly recommended as a pre-treatment step prior to Nanofiltration and Reverse Osmosis operations highly sensitive to colloids and suspended solids causing bundle clogging. Micro-Ultrafiltration may be carried on under very flexible methodology including frontal filtration mode or tangential mode when the suspensions contain a large range of compounds [3-6] obliging specific conditioning to minimise fouling [7]. In water treatment most of fouling is caused by suspended matter and colloid fractions deposit on membrane surface or by pore blocking. Suspension conditioning such as coagulation-flocculation, adsorption and oxidation step is then favourable. Nevertheless according to the raw water characteristics, it appears important to minimise the operating cost by optimising the conditioning conditions, the membrane module configuration and the hydrodynamics. Immersed membrane systems present several advantages because of the module configuration directly immersed in the tank where raw water is introduced in presence or not of any physico-chemical conditioning. The external membrane fouling can be controlled under low energetic cost by air injection as turbulence supplier and the permeate flux level can be achieved over a relatively long operational period without or less chemical cleaning [5,6,8]. The objective of this work was to quantify the importance of operational conditions, water compositions, sheer stresses generated by aeration and chemical conditioning, on the membrane fouling control in an immersed system. And the impact of operational conditions on the membrane fouling dynamics was evaluated by measuring specific hydraulic resistance using the cake filtration model.

MATERIALS and METHODS

The experiments were carried on in a 40L lab scale pilot equipped with immersed membrane module packed with polysulfone capillary fibres (0.1 µm pore size and a 0.1 m^2 filtering surface). Surface water and synthetic salted water adding with 0.05 to 5.0 g/L bentonite particles were used as suspensions. Surface water and salted water had the following characteristics: 5-10 NTU turbidity, 0.1-0.3 UV-254, 30-40 Pt-Co color and 10-1,000 NTU, 12-1,200 Pt-Co color, 30 ppt salinity. Aeration was provided by distributor placed under the membrane module, the generated bubbles throughout the fibre network and the suspension was stirred by an impeller. The different types of coagulants, $FeCl_3$ Alum and PACl, were used to induce coagulation of suspended particles and the chosen doses were chosen at optimum and lower than the optimum values. The membrane performances were investigated according to the critical flux notions [9] and evaluation of TMP variations with time. The fouling potential of studied suspensions was investigated and their filterability was quantified in frontal filtration mode using a lab scale filtration unit equipped with plane organic membrane (0.1-0.05 µm pore size). Cake filtration model was used to evaluate fouling potentials. The methodology consisted in following up the cumulated volume of filtrate during filtration time for a given TMP.

RESULTS

The results clearly showed the positive effect of a $FeCl_3$ conditioning. When the suspension was conditioned by $FeCl_3$ adding, a permeate flux over 100 L/h/m^2 was obtained under a 0.5 bar TMP, which was 2-3 times more intensive than results obtained when using other types of coagulants. In this condition an air injection did not actually modify the permeate flux. Moreover, a small amount of added $FeCl_3$ 10 mg/L, lower than 50% of optimum dose, was sufficient to intensify the filtration, the permeate flux enhancement occurred higher 2-3 times than without any coagulation. In any case when conditioning with $FeCl_3$, it was not necessary to supply high air flow rates. In the condition working with salted water, the critical flux reached close to 40 L/h/m^2. This decrease in performances is probably due to the high ionic strength of salted water that modifies the interactions between suspended solids and coagulant and then the floc characteristics differ from flocs occurred in surface water. However, the filtration of salted water highly concentrated in 5.0 gSS/L did not induce quite different values of critical flux, 34 L/h/m^2, what confirmed the benefit of $FeCl_3$ on flux enhancement. In these conditions, high rate of aeration, 70 L/min, promoted some increasing of the flux values about 42 L/h/m^2. The hydraulic resistance values confirmed the role of the $FeCl_3$ adding. The conditioned suspensions let appear specific resistance (αW and α) 2-10 lower than the values obtained by direct filtration of raw suspensions without or with alum conditioning. The particles deposit on the membrane appeared very reversible. The low porosity and weak density of the cake structure composed by conditioned flocs retained on the membrane surface may represent a dynamic layer able to retain colloids and some soluble fractions and induces low hydraulic resistance. In salted water, the specific hydraulic resistance gave lower values of αW than observed in surface water. In all tested conditions the filtered water showed a very good clarification quality with turbidity values lower than 0.5 NTU.

CONCLUSION

The Immersed Membrane System appeared as an appropriated operation to obtain very high quality of water clarification whatever the raw water quality (even with salted water), this property appears then determinant when a nanofiltration or a reverse osmotic step must be developed as a final or polishing step. The filtration step appeared as very sensitive to suspension conditioning. In the chosen operational conditions the $FeCl_3$ conditioning appeared as very efficient with the high permeates flux obtained under low TMP (0.1 m^3.m^{-2}.h^{-1}). On the other hand, the $FeCl_3$ conditioning induced flocs structure with large porosity and low density, this floc deposit played the role of a dynamic membrane that reduced the irreversible fouling phenomena.

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