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Limitation of Hardness from Thermal Water by means of Nanofiltration

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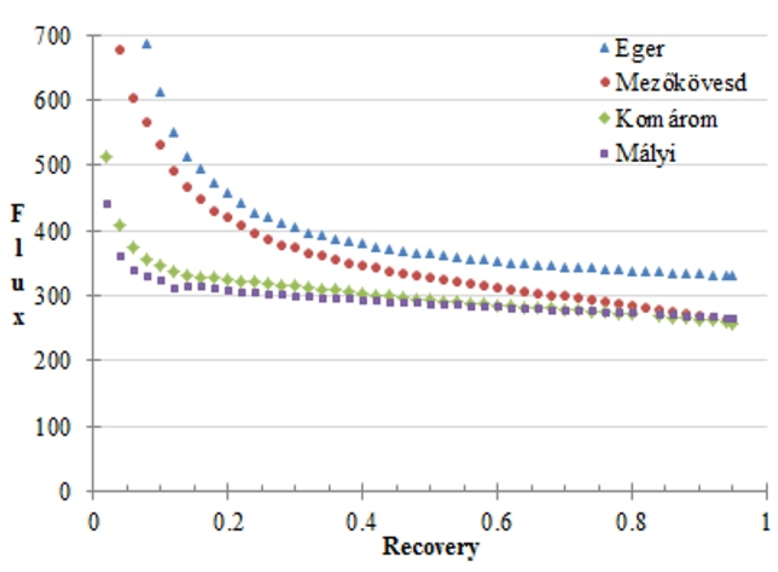
INTRODUCTION

Geothermal conditions are extremely favourable in Hungary. Thermal water is accessible on 70% of the territory of the country, at lowest temperature of 30°C. For energetic purposes, it can be utilized in two different ways: for supplying heat or generating electricity (Mádl-Szőnyi et al., 2008). Regarding the given conditions in Hungary, the former can have particular importance. However, numerous problems arise in connection with this application, among which probably the most serious one is scaling resulting from the chemical composition of thermal water. Many physical and chemical methods are available for reducing carbonate hardness (Ghizellaoui et al., 2005), but most of them cannot be applied or have many disadvantages in terms of utilization and the subsequent reinjection. The opportunities of preventing scaling by nanofiltration in batch mode is investigated in this paper. The scaling properties of thermal water were simulated with the help of a chemical equilibrium modelling software.

RESULTS AND DISCUSSION

Thermal water of different origin

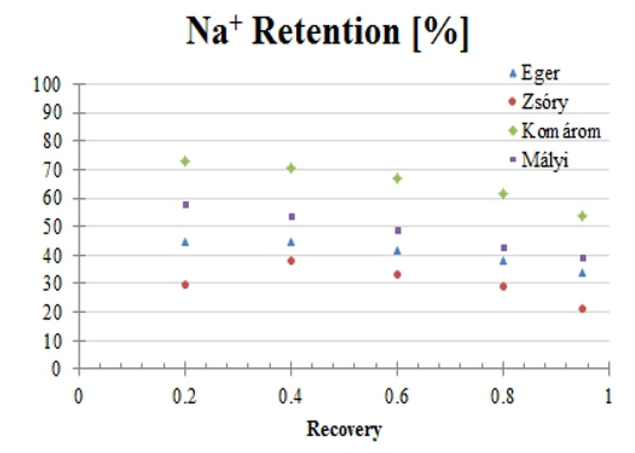
Permeate flux

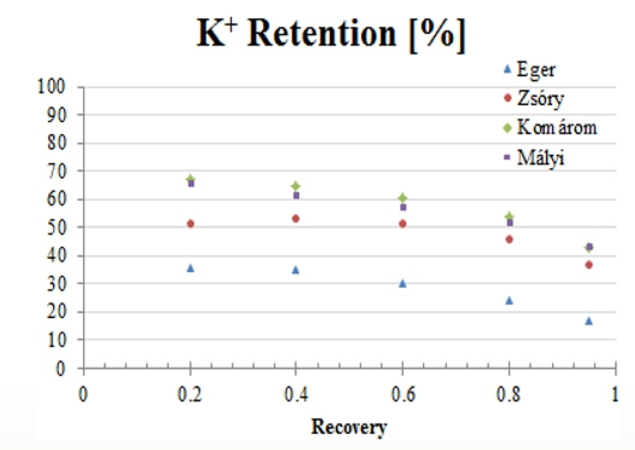


Applied membrane	DK (GE Osmonics)
Operating temperature	50°C
Operating pressure	3.5 MPa

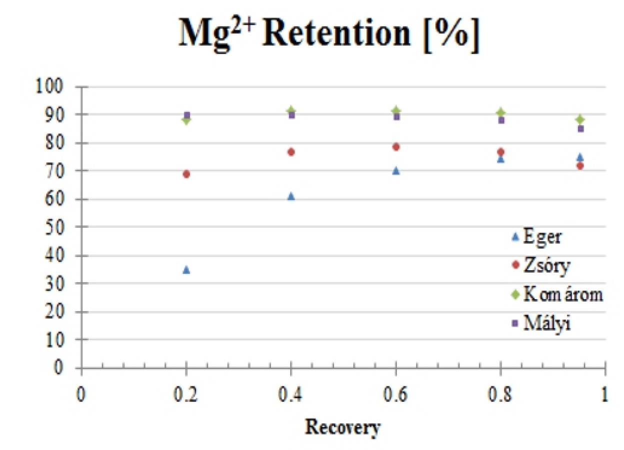
- Membrane recovery is defined as the ratio of permeate flow to feed flow
- Permeate flux is expressed in [$dm^3/(m^2h)$]
- After the initial significant drop of flux, a continuous slight decrease can be observed due to the reduced driving force caused by the increasing osmotic pressure (Schaep et al., 1998)

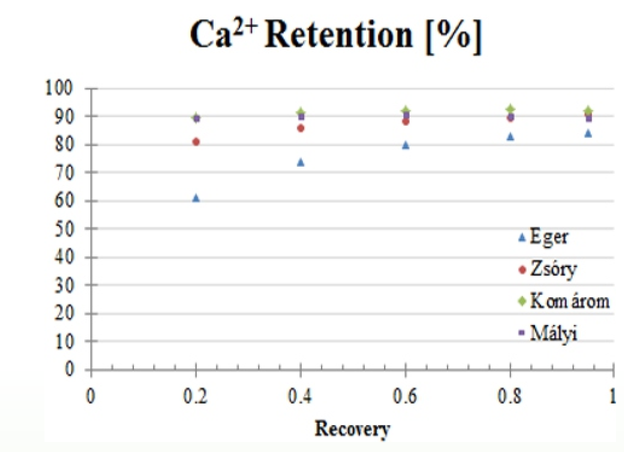
Retention of monovalent ions





Retention of divalent ions



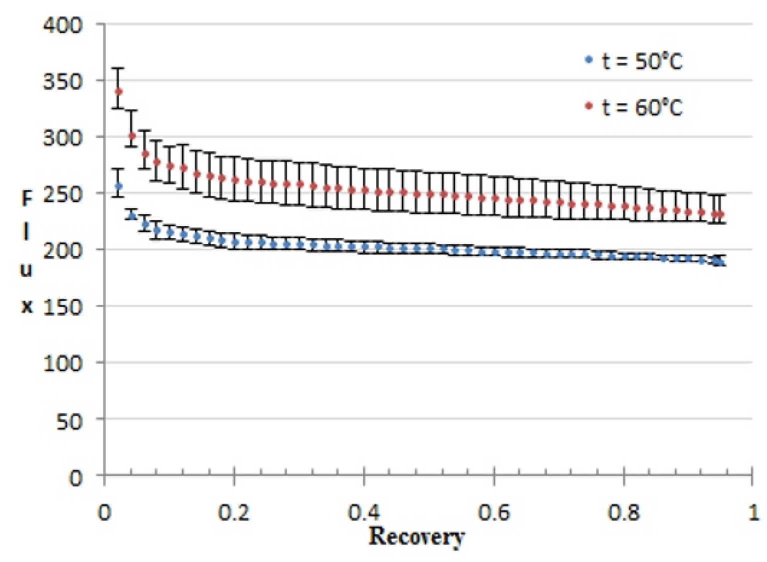


- Rejection of monovalent ions is much lower than rejection of divalent ones (due to the membrane selectivity)
- Retention of monovalent cations decreases with increasing recovery

- Rejection of divalent ions is relatively high
- Mg^{2+} retention increases as recovery increases in the case of Eger, decreases in the three other cases
- Ca^{2+} retention increases obviously with increasing recovery

Reproducibility experiments

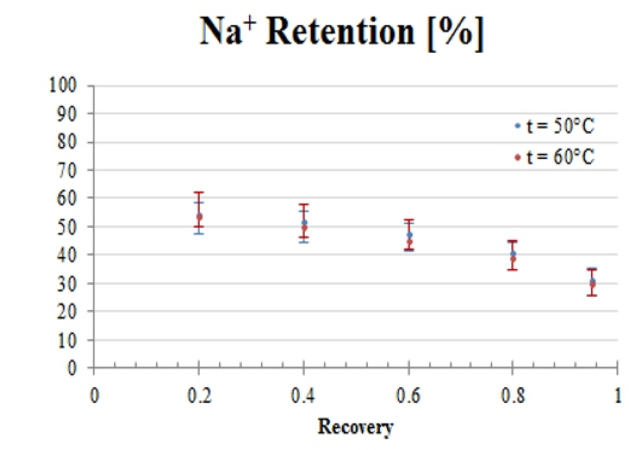
Permeate flux

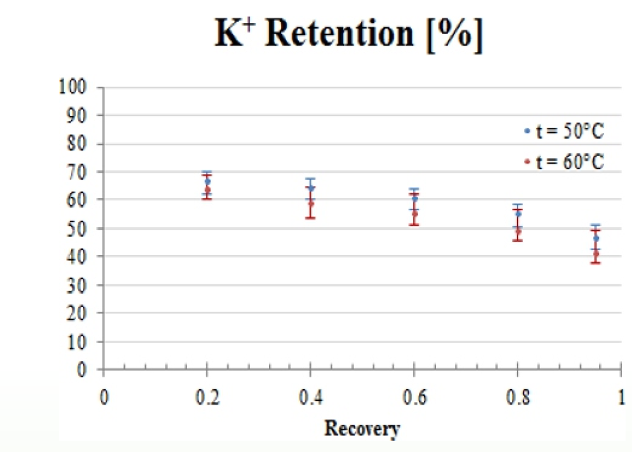


Applied membrane	DK (GE Osmonics)
Operating temperature	50°C and 60°C
Operating pressure	3.5 MPa

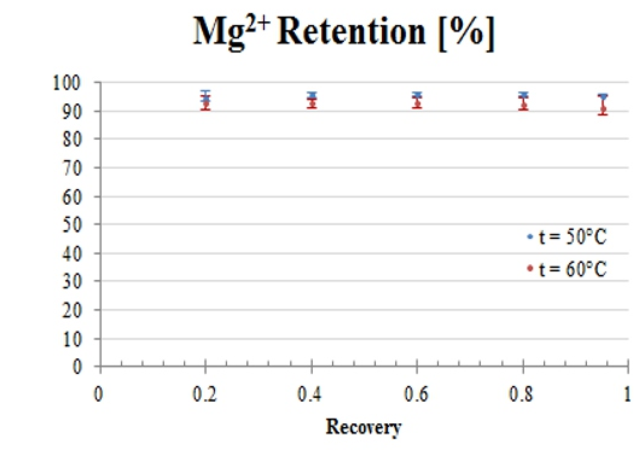
- Fluxes stay approximately the same during experiments performed under the same conditions
- Higher flux can be observed at higher temperature (since viscosity tends to fall as temperature increases and flux is in inverse ratio to viscosity) (Membrane Technology and Applications, 2004)

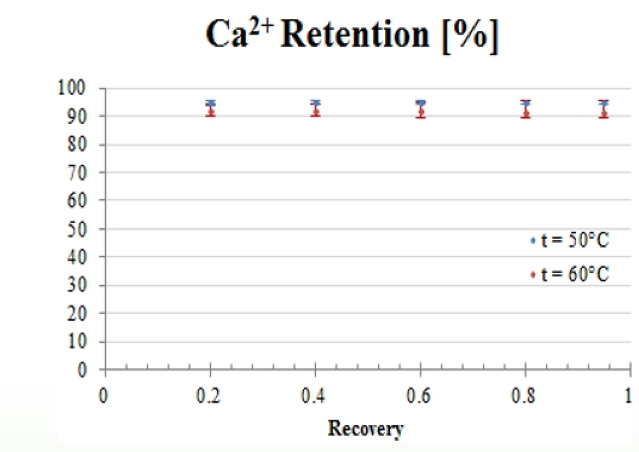
Retention of monovalent ions





Retention of divalent ions

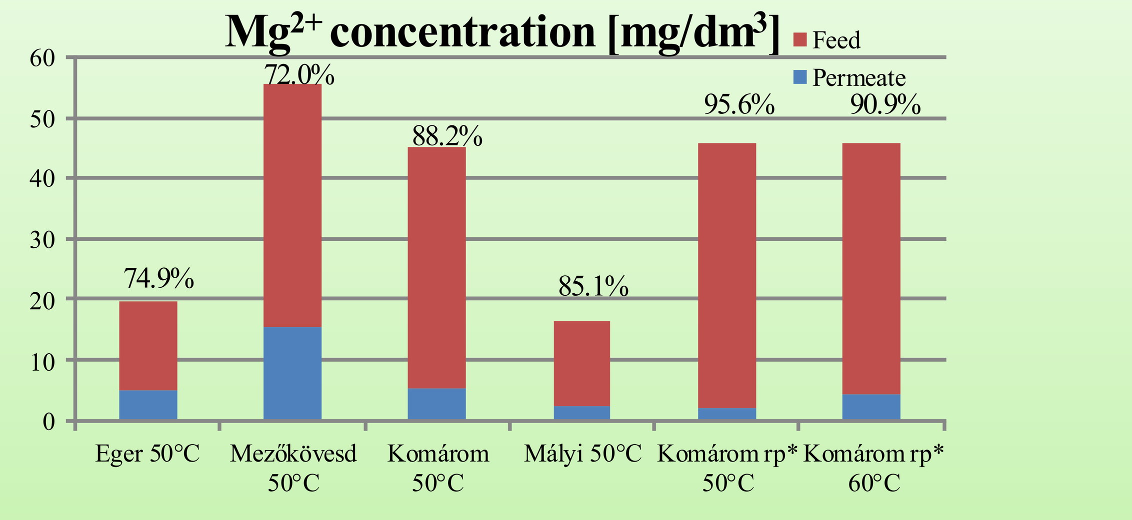


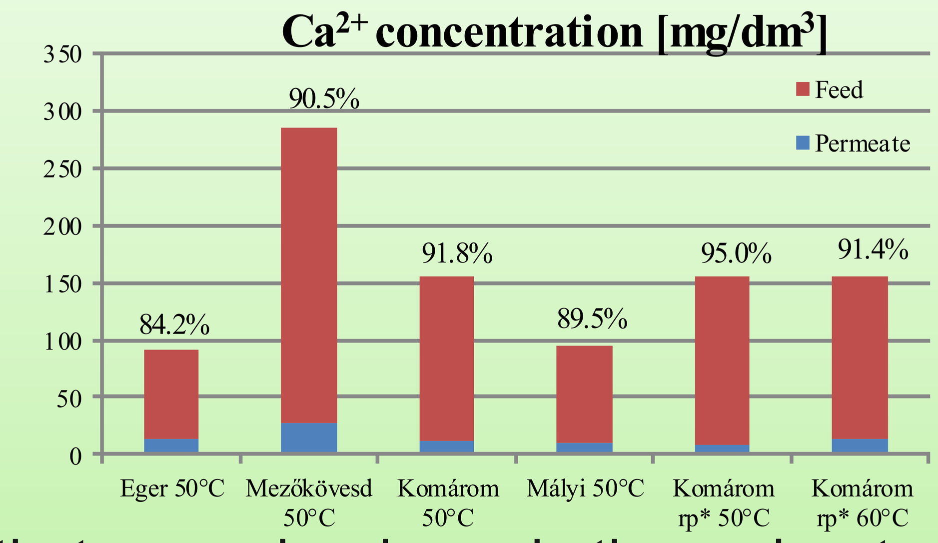


- Relatively low rejection of monovalent ions can be seen
- Smaller values can be observed at higher temperature
- Retentions stay approximately the same throughout measurements performed under the same conditions

- Both rejections are above 90% in each case
- Smaller values can be observed at higher temperature
- Retentions stay approximately the same throughout measurements performed under the same conditions

SUMMARY





- Nanofiltration is capable of removing cations that cause hardness in thermal water
- Chemical equilibrium modelling (Visual MINTEQ 3.0) indicates no scaling in permeates appear
- Application of this separation process in practice requires more investigations in order to optimize the process parameters, such as the rate of recovery in order to avoid the precipitation on the surface of the membrane and the applied transmembrane pressure to find the cost-effective operation

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