Predicting Contaminant Rejection by Nanofiltration with a Phenomenological Model

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Background

Prior to the installation of a full-scale membrane system, it is useful to know how effective it will be at removing contaminants. This can be determined using either bench-scale systems which are valuable due to their low installation cost. However, these bench-scale systems (Figure 1) are much simpler than full-scale systems (Figure 2) and may not be representative of the actual rejection.

This problem may be solved by using bench-scale data to model full-scale rejection. Most of the modeling to predict rejection at the full-scale is done using data collected from the bench-scale. One approach is a phenomenological model, which had the advantages of being applicable to porous and nonporous membranes and reduced computational effort.

Figure 1. Bench-scale membrane system

Figure 2. Full-scale membrane system

Objectives

1. Develop a model to predict performance of a membrane system at the full-scale
2. Determine if parameters obtained at the bench-scale can be used to model rejection at the full-scale

Methods

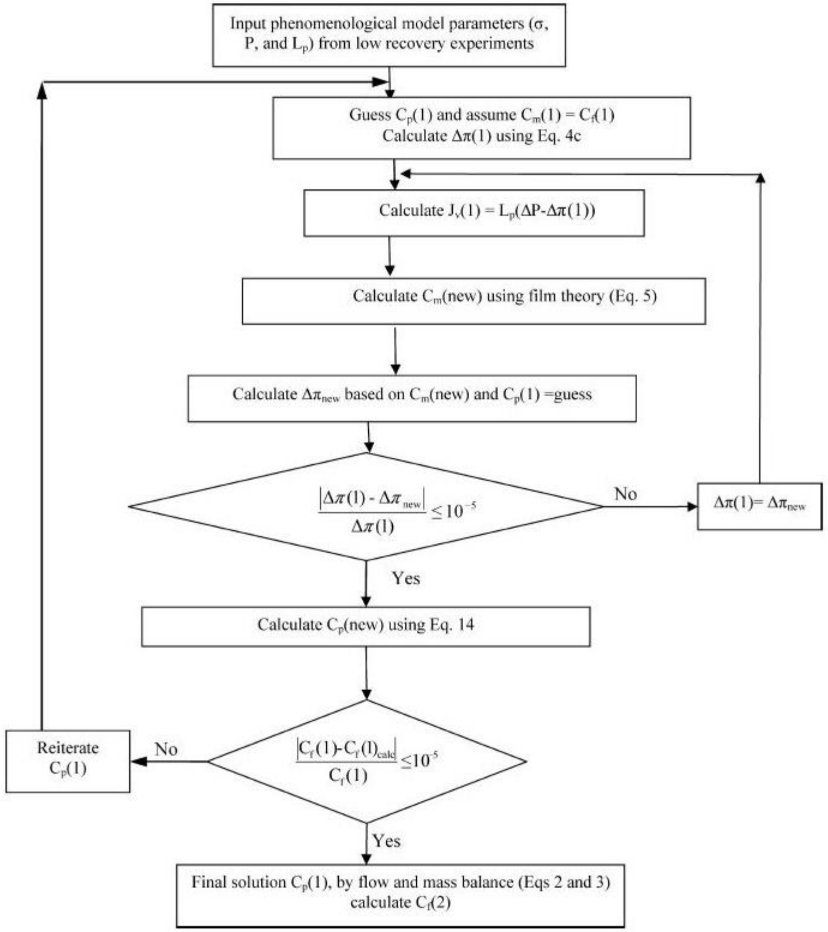

Figure 3. Flow chart providing basis for code (Sharma and Chellam 2008)

In 2011, bench-scale testing was performed to measure rejection of 19 contaminants by an NF membrane (NF270, Filmtec). Data collected from these experiments were used to determine parameters needed to predict contaminant rejection by the membrane. These parameters are referred to as sigma and permeability. In 2012, a code based on the phenomenological model (Figure 3) was developed to predict rejection at the full-scale. In the summer of 2020, this code was updated to work with the current version of MATLAB. Another version was made to adjust the sigma and permeability values until the modeled rejection values matched the pilot-scale rejection data.

Results

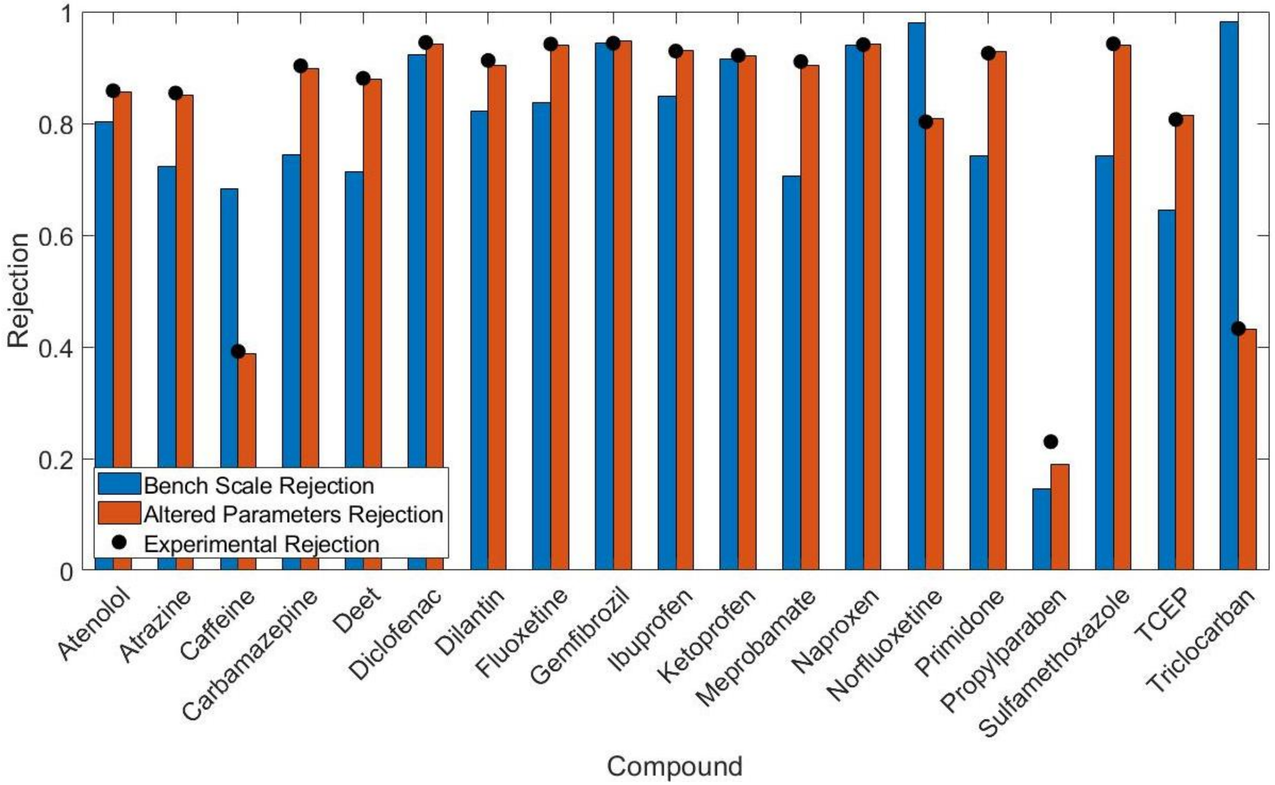

Figure 4. Rejection results from the model and full-scale results

Conclusions

It was found that parameters derived at the bench-scale generally caused the model to underpredict rejection at the pilot-scale. For contaminants with low measured rejection, such as triclocarban, the model was found to overpredict rejection. However, it was possible to adjust the parameters to make the model more accurately predict rejection at the full-scale.

Future Work

It is recommended to redo this experiment to collect more data at the bench-scale and full-scale. This should be used to determine new parameters at the bench-scale to use in the model. This can be compared with the new- full-scale data to determine if the new data is more accurate.

If this does not produce more accurate results, it is recommended to determine why parameters obtained at the bench-scale do not accurately predict rejection at the full-scale.

References

Sharma, R. R. and Chellam, S. (2008). “Solute rejection by porous thin film composite nanofiltration membranes at high feed water recoveries.” J Colloid and Interface Sci. 328(2), 353-366.

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