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DRFM hybrid model to optimize energy performance of pre-treatment depth filters in desalination facilities

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1. Background

Depth filtration is a common pre-treatment technology in desalination facilities. During effective pre-treatment, physical clogging of the filter's voids occurs which complexity remains a challenge to quantify. Engineering modelling of the clogging problem is important as it helps engineers to perform predictive maintenance based on the filter's energy requirements. By doing so, both materials and energy savings can potentially be realized.

2. Objective of study

To achieve predictive maintenance of depth filters, a hybrid dynamical rapid filtration (DRFM) model is developed in this study to quantify the complex clogging behavior and filter' energy requirements over time.

3. Hybrid DRFM model development

Figure 1 illustrates the hybridization of two self-developed empirical models: (a) R_c model equation; and (b) DRFM.

R_c model equation → pre-configure engineering design of depth filter

DRFM → compute energy requirements of pre-configured filter design

A numerical algorithm is implemented to combine both models which then iterates the optimized filter design to minimize its energy requirements for the known intake conditions, and achieve economies of scale (EOS).

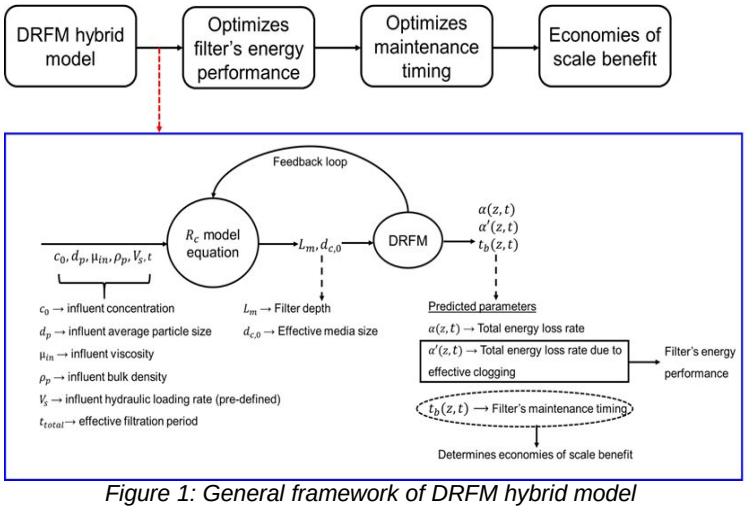


Figure 1: General framework of DRFM hybrid model

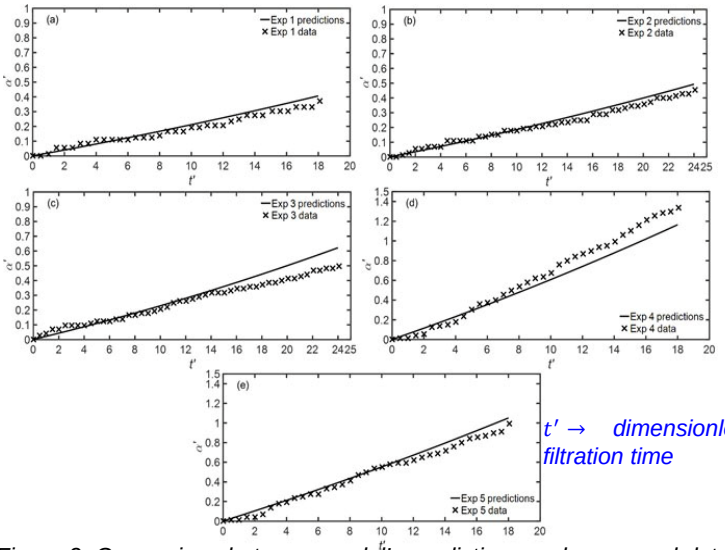
4. Model verification

Model's predictions are compared with measured data for the energy requirements of our own lab-scale filter setup. Table 1 lists the operational conditions for the influent's concentration (c_o), particle size (d_p) and hydraulic loading rate (q_{in}). Other conditions were kept constant.

Table 1: Operational conditions for lab-scale rapid filter

Exp no.	q_{in} (m/h)	Tur_{in} (c_0) (NTU)	TSS (c_0) (mg/L)	d_p (μm)	Duration $(mins)$
1	6.0	78.8	158	50	90
2	6.0	68.0	140	50	120
3	6.0	86.1	170	50	120
4	6.0	75.6	151	20	90
5	6.0	63.6	127	20	90

Figure 2 shows reasonable agreement between the model's predictions and measured data in each filter run, with an average error deviation of between 10 to 20%.



t' → *dimensionless filtration time*

Figure 2: Comparison between model's predictions and measured data in each filter run: (a) Exp 1; (b) Exp 2; (c) Exp 3; (d) Exp 4; (e) Exp 5

5. Closing remarks

More details about model's capability: (a) to pre-configure filter's design to minimize energy requirements; (b) to predict any filter's optimized maintenance time, can be found in paper of Chew and Law (2018).

Chew, A. W. Z. and Law, A. W. K. 2018, DRFM hybrid model to optimize energy performance of pre-treatment depth filters in desalination facilities, *Applied Energy*, 220: 576-597.