NATURAL ORGANIC MATTER REMOVAL FROM SURFACE WATER USING SUBMERGED ULTRAFILTRATION MEMBRANE UNIT

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ABSTRACT

This research is conducted to provide quantitative and qualitative integrated understandings of natural organic matter (NOM) fouling characteristics regarding to mechanisms and factors involved, and as well as to develop an optimization works for surface water treatment. In conjunction, a fouling behaviour and autopsy protocol for ultrafiltration membrane fouled with natural organic matter source waters were studied. The Ulu Pontian river, Bekok Dam water and Yong Peng water were used. Fouling characteristics were assessed by filtering the feed water with an immersed ultrafiltration polysulfone and cellulose acetate membranes that were spun by a dry-wet phase inversion spinning process. Relatively hydrophilic NOM source exhibited greater flux decline (72%) but lesser natural organic matter removal (17%) considerably due to pore adsorption, indicating that the low molecular weight (7%>30 kDa), aliphatic linear structure and neutral/base organic matter contained within the hydrophilic fraction were the prime foulants. In contrast, relatively hydrophobic natural organic matter source water that possessed higher charge density (22.63 meq/gC), greater molecular weight (24%>30 kDa) and bulky aromatic structure has shown lesser flux decline (Bekok Dam: 57%) and better NOM rejection (37%) noticeably due to cake deposition, despite filtering through a hydrophobic membrane, suggesting that the electrostatic repulsion was more influential than the steric hindrance. In comparison, a non-charged model compound of similar molecular weight was used to quantify the role of charge repulsion on NOM rejection. However, hydrophobic organic matter source of Yong Peng water has demonstrated the opposite results (flux decline: 77%), presumably due to the governing adsorptive fouling which offsett the electrostatic interactions. Analyses of permeate characteristics revealed that the hydrophobic NOM was preferentially removed by the membrane as opposed to the hydrophilic natural organic matter, hence suggesting that the charge interactions, in addition to size exclusion were more crucial to natural organic matter removal. These findings were consistent with the surrogated and fractionated natural organic matter results, which showed the hydrophilic component exhibiting the highest flux decline (52%) despite lesser dissolved organic carbon (14%) and ultraviolet$_{254}$ removal (23%) compared to hydrophobic (35%) and transphilic fractions (20%). Membrane autopsies analyses confirmed the flux decline results, resistance-in-series and permeate analyses as membrane was mainly fouled by the hydrophilic natural organic matter rather than humic compounds. Adequacy of the present quadratic models were statistically significant to represent both the natural organic matter removal (R^2=0.966; F=49.36) and membrane permeability (R^2=0.886; F=13.33). Alum dose exhibited the most significant factor that influenced the natural organic matter removal, followed by the two level interactions of pH and specific ultraviolet absorbance, the main effect of pH, the main effect of specific ultraviolet absorbance, the two level interaction of specific ultraviolet absorbance and alum, the second order effect of specific ultraviolet absorbance and the second order effect of pH. In the case of membrane permeability, the main effect of alum dosage and the second order effect of pH provided the principal effect, whereas the second order effect of alum, the main effect of pH, the two level interaction of pH and specific ultraviolet absorbance provided the secondary effect. Permeate quality surpassing the National Drinking Water Standards was achieved with removal up to 79.50 % of dissolved organic carbon, 87% ultraviolet absorbance, >96% of colour >99% of turbidity and with effective-cost of RM 1.12/m^3, suggesting it is cost-competitive compared to conventional water treatment.

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