Membrane Filtration for Sustainable Safe Drinking Water Supply—Modeling of Particle Rejection

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Membrane filtration process has become increasingly popular as the effective barrier against suspended solids and pathogenic microorganisms in surface water, and thus, is one of the proper processes for securing safe drinking water supply. Estimation of particle rejection and release through membrane filtration is important issue for evaluating the health risk associated with pathogenic microbes released into the filtrate.

Currently, particle rejection phenomenon including microorganism particles by membranes has been explained based on the assumption that the pore has the cylindrical structure (Hagen-Poiseuille flow model). However, the problem is that this assumption cannot be applied to the porous structured membrane with widely distributed pore sizes which has nowadays become widely used. Thus, understanding and proper estimation of particle rejection and release by porous structured membrane are required.

For estimating particle rejection and release through porous structured membrane, the challenge is the complexity associated both with the distribution of the particle size and three-dimensional distribution of membrane pore structure; natural water contains colloids and particles together with pathogenic microbes with broad range of size, porous membrane has a certain distribution of pore size due to the synthesis method, and the pore size distribution changes through filtration of particles.

To estimate the complex particle rejection phenomenon under these conditions, the novel particle rejection model for porous structured membrane has been developed with the relatively simple assumption; the porous membrane has multi-layered structure and the probability of particle rejection by each layer was determined by the ratio between each particle size and distribution of pore sizes at each filtration moment. The time course of change of pore size distribution and particle rejection ratio by each layer was simulated for cases of monodisperse and polydisperse conditions. The developed model could explain the rejection phenomenon of particles with the size smaller than nominal pore size of membrane due to the rejection inside the membrane, and could be useful tools to estimate the rejection and release of particles through the porous structured membrane filtration. This study indicates that utilization of larger pore sized membrane is effective even for removal of smaller particles with much lower energy requirement compared to the filtration with smaller pore sized membrane.