Biofouling on Membranes ~ Causes, Consequences and Control

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Biofouling is a significant problem in membrane processes, such as reverse osmosis (RO) desalination and reclamation and wastewater membrane bioreactors (MBRs). RO biofilms develop from adhering bacteria passing through pretreatment, combined with adequate levels of nutrient. For constant flux operation the biofouling leads to an increase in required pressure to overcome both hydraulic resistance and cake enhanced osmotic pressure; the latter is worse at high salinity. It has also been shown that in spiral wound modules biofouling can be both a membrane issue and a spacer issue. There is some debate as to the relative significance of the two types of biofouling, and this will be reviewed. In MBRs fouling from the mixed liquor is a combination of filtered foulants (SMP, EPS and colloids etc) and biofouling caused by colonization of planktonic bacteria coming to the membrane. For constant flux processing the transmembrane pressure (TMP) rises steadily and eventually experiences a rapid increase (the TMP jump). The TMP jump has several explanations including cake enhanced osmotic pressure effects from macromolecular components retained by the fouled membrane. In the MBR an osmotic effect of only 20 to 30 kPa can be significant. The control of biofouling in RO will be discussed in terms of the effectiveness of various pretreatment options, including UV, to remove or inactivate the bacteria in the feed. The importance of flux in determining the rate of biofouling can be explained in terms of the increased concentration of nutrients due to concentration polarization. This phenomenon can be self accelerating. Recent studies will be described on biofilm dispersion using chemically based signaling systems that many bacteria use to regulate the formation of fouling biofilms. Biofouling in MBRs cannot be avoided but its effects can be modified. Strategies include selection of a 'sustainable' flux, control of the hydrodynamic environment by bubbling, and control of the biomass conditions. To control the latter involves use of an appropriate sludge retention time and considering use of supported biomass. Recent attempts at biofouling control in MBRs using chemically based signaling systems will be reviewed.