Executive summary

Removal of phages and nanoparticles by ceramic membranes

Introduction

Applications of micro- and ultrafiltration membranes in drinking water treatment showed a considerable increase in recent years. The membranes are used to remove particulate matter such as inorganic particles as well as microorganisms including bacteria and viruses. Examinations of mechanisms for virus removal during membrane filtration is of practical importance especially if no flocculants are applied, because of their small size of about 20-30 nm.

Importance

Micro- and ultrafiltration membranes, which are currently in operation in European waterworks are made from organic materials. Recent developments showed that membranes made from inorganic materials could be promising in membrane technology in the future, due to their unique characteristics such as a hydrophilic surface or a high resistance against mechanical, chemical and thermal stress.

Approach

This study examined the removal of natural occurring nanoparticles including phages by ceramic membranes. The influence of steric and charge mechanisms on removal of particles in the size range of viruses (nanoparticles) was studied during filtration with ceramic membranes without usage of flocculants. Micro- and ultrafiltration membranes were considered, which were made from different materials including Al_2O_3, SiC and TiO_2. Removal of phages was studied with biological (cultivation, PCR) and physical (breakdown detection) methods.

Result

Phages removal by filtration with ceramic membranes was mainly influenced by size exclusion mechanisms. However, other mechanisms may influence the efficiency of phages removal, too. Under conditions of the study ceramic membranes showed a 0.5 to 0.9 log higher log-removal for negatively charged *MS2*-phages compared to the uncharged *ΦX174*-phages, despite of the same diameter for both phages. Comprehensive examinations of the actual membrane surface charge, e.g. by Zeta-potential, to confirm the membrane charge

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expected from the membrane material would support the identification of the basic mechanisms, which are responsible for the observed effects.

Pre-fouling was found to improve the removal of *MS2*-phages slightly for the 50 nm ultrafiltration membrane. This result could be due to size exclusion of fouled pores. However, no effect of pre-fouling was measured for the 200 nm SiC/SiO_2-membrane.

Comparison of log-removals determined by cultivation methods for phages and detection of nanosized particles by LIBD-technique showed a relatively good agreement. Therefore, LIBD nanoparticle analysis might be a suitable method for membrane integrity control even for particles in the size range of viruses.

Organic matter from CIP waste of membranes was characterized by fluorescence analysis in addition to LCOCD-analysis. Both analytical methods are independent on each other. They showed a different composition of organic material in CIP-waste for ceramic compared to polymeric membranes. These results support the findings that fouling mechanisms between ceramic and polymeric membranes are different.

More information

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Name of author(s):	Uwe Mueller Ralf Schaefer Claudia Zawadsky Karin Boeckle Monika Boesl Ingrid Eberhagen Beate Hambsch
Organization:	DVGW Water Technology Center (TZW) http://www.TZW.de
Contact person:	Uwe Mueller
Telephone number:	+49/(0)721-9678-257
Email:	mueller@tzw.de

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