

Membranes show potential for removing antibiotic resistant genes from wastewater

Treatment Processes for Removal of Wastewater Contaminants: Effect of Wastewater Colloids on Membrane Removal of Antibiotic Resistance Genes (INFR8SG09)

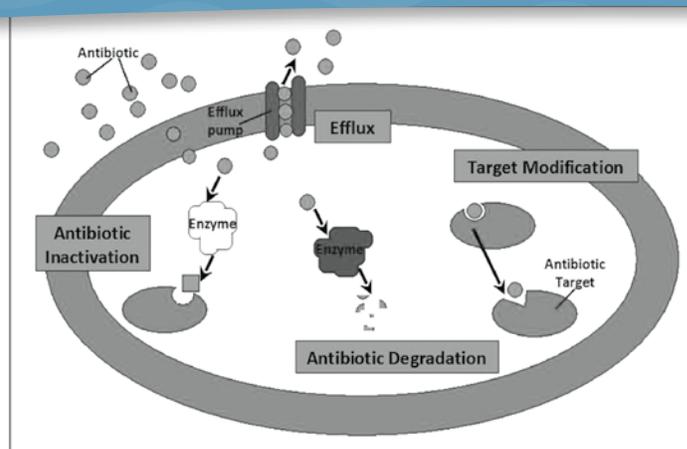
The Central Issue

Antibiotic resistance genes (ARGs) are the causative agents of the critical human health challenge of antimicrobial resistance. Hospital-acquired infections caused by antibiotic-resistant bacteria are not only the leading cause of increased mortality and morbidity among patients, but are also contributing to the increased costs of hospital treatment. ARGs find their way into wastewater and can persist in the environment outside their bacterial host cells as extracellular DNA, often in clusters, and can be transferred to new host cells. This facilitates their ability to spread within bacterial populations. This research looks at how wastewater treatment can be an effective barrier in limiting the spread of antibiotic resistance by removing or destroying DNA that causes the bacteria to be resistant.

Context and Background

Bacterial DNA is constantly being expelled from the cell, and that extracellular DNA (eDNA) is a vital component of the extracellular polymeric substances that bind bacterial biofilms like those found in biological treatment. Of particular interest is the potential effect of wastewater colloids on membrane removal of ARGs, as it has been previously shown that eDNA from various sources adsorbs to various colloidal particles. Although a few studies have been carried out concerning the behavior and fate of eDNA in highly simplified systems, there exists a significant knowledge gap in the behavior of eDNA in natural systems. Such fundamental understanding is critical in optimizing the potential for ARG to be removed from wastewater treatment plant effluent. The present research set out to determine the degree of association of ARGs with various colloidal sizes and to determine the removal efficiency of these colloids in wastewater treatment plants that use membranes.

Another important implication of colloid-enhanced membrane removal of ARGs, is the potential for cost and energy savings. If ARGs, or for that matter any contaminant, associate with



Antibiotic resistance mechanisms include: efflux pumping of antibiotics out of the cell, degradation of the antibiotic, modification of the antibiotic target, and modification of the antibiotic. These resistance mechanisms are encoded by antibiotic resistance genes, which can spread among different bacteria in the wastewater treatment process and in receiving environments.

wastewater colloids, then removal may be possible with larger diameter (looser) membranes, which incur less cost and energy. If the ARGs are associated with the larger size fractions, then more conventional treatment processes can be used. If the ARGs are associated with the smaller size fractions, advanced processes such as nanofiltration or activated carbon may be needed.

Findings and Conclusions

A positive outcome of this study is that membrane removal of ARGs is not only feasible, but it is enhanced in the presence of wastewater colloids. The removal of colloid-associated ARGs from wastewater was primarily associated with the removal of colloids between 0.10 μ m and 100kDa in size. This size range is removed by activated sludge with nitrification/denitrification.

The application of a membrane filtration polishing step in wastewater treatment would not only help alleviate the problem of the spread of ARGs, but can also be extended to the removal of other colloid-associated wastewater constituents such as some pharmaceuticals (e.g., antibiotics, estrogenic compounds) and engineered nanomaterials. Membranes would also directly enhance removal of pathogenic bacteria and viruses.

The benefits of ARG and other colloid-associated wastewater constituent removal must be weighed against the energy demands associated with tighter membranes. This study provides valuable knowledge to guide optimal membrane selection for removal of ARGs in real-world wastewaters.

Executive Summary



Treatment Processes for Removal of Wastewater Contaminants: Effect of Wastewater Colloids on Membrane Removal of Antibiotic Resistance Genes

Management and Policy Implications

Fundamental new insight into the potential for membrane removal of ARGs from wastewater treatment plant influent is provided in this study. The findings suggest that although tighter membranes are required for ARG removal than would be predicted based on molecular weight alone, looser membranes may still be effective given the water chemistry of real-world wastewater treatment plant

effluents and the prevalence of colloidal material. The benefits of removal must be weighed against the energy demands associated with tighter membranes. This study provides critical knowledge to guide optimal membrane selection for removal of ARGs in real-world wastewaters. Wastewater treatment may provide a cost effective barrier against the dissemination of antibiotic resistance.

Related WERF Research

WERF has done other membrane research, for example, demonstrating the feasibility and application of the membrane bioreactor (MBR) process for wastewater treatment and water reclamation. However, this ARG research explores a new way of thinking about pathogen control in water treatment. It is unique in WERF's research portfolio and is very much in line with the innovative treatment technology objectives of WERF's Water Infrastructure for the 21st Century research program.

Principal Investigators:

John T. Novak, Ph.D., P.E.
Peter Vikesland, Ph.D.
Amy Pruden, Ph.D.
Virginia Polytechnic Institute & State University

Technical Reviewers:

Zia Bukhari
American Water
Kendall M. Jacob, P.E. (IIRC)
Cobb County Water System

Samuel S. Jeyanayagam, Ph.D., PE, BCEE
CH2M HILL

Patrick Jjemba, Ph.D.
American Water

To Order

Contact WERF at 571-384-2100 or visit www.werf.org and click on Search Research Publications & Tools.
WERF Subscribers: Download unlimited free PDFs. Non-Subscribers: Charges apply to some products.

Refer to: Stock No. **INFR8SG09**
For more information, contact
Walter Graf at wgraf@werf.org.

