Antimicrobial Resistance Removal Efficiency of Membranes

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Abstract

Antimicrobial resistance (AMR) is the ability of microorganisms such as bacteria, fungi, viruses, or protozoa to inactivate antibiotics. The urban water cycle is one of the major routes of AMR distribution because antibiotic resistant bacteria (ARB) and antibiotic resistance genes (ARGs) end up in the urban water cycle through wastewater discharge or manure applications and associated unintended run-off from agricultural land. In this work, AMR removal efficiency by membrane systems is investigated. Membrane filtration is one of the effective treatment methods for AMR removal among wastewater treatment methods.

Keywords: Antimicrobial Resistance; Filtration; Membrane Bioreactors; Microfiltration; Ultrafiltration; Wastewater Treatment

1. Introduction

Antibiotics have been used extensively for decades to treat infections in animals and humans since the discovery of penicillin (Davies and Davies, 2010). Antimicrobial resistance (AMR) is the ability of microorganisms such as bacteria, fungi, viruses, or protozoa to inactivate antibiotics. AMR causes more than 700,000 deaths each year, and this number is predicted to reach 10 million by 2050. (Meredith et al., 2015).

Although microorganisms are the primary source of antibiotics, the same microorganisms develop antibiotic resistance against them (Davies and Davies, 2010). In natural ecosystems, antibiotics are used in very small concentrations for communication purposes (Martinez, 2008). It is also produced and used in higher concentrations by microorganisms to fight and defend themselves against the bacteria they compete with (Martinez et al., 2015). Not all microorganisms produce antibiotics, but microorganisms that produce antibiotics have evolved to be resistant to antibiotics in order not to be inhibited by the compounds they produce (Blair et al., 2014).

AMR is not limited to antibiotic producing microorganisms. Resistance ability is encoded in antibiotic resistance genes (ARG), so it is possible to transfer it between bacterial communities via horizontal gene transfer (HGT). For antibiotics to kill and inhibit bacteria, the microorganism must be sensitive to these compounds. However, pollution of the environment with antibiotic compounds by human activities provides a competitive advantage to antibiotic resistant bacteria (ARB) against other bacteria and gradually changes the resistome in the natural environment (Xie et al., 2018).

The urban water cycle is one of the major routes of AMR distribution because ARB and ARGs end up in the urban water cycle through wastewater discharge or applications of manure and and associated unintended run-off from agricultural land (Chow et al., 2015). The aim of this work is to investigate existing literature on membrane filtration systems in terms of AMR removal performances.

2. Material and Methods

The urban water cycle is one of the major routes of AMR distribution in the environment. Hence, ARG and ARB in the water sources and wastewater must be removed before usage. In this work, a comprehensive literature survey was conducted to determine the AMR removal efficiency by membrane systems.

3. Results and Discussion

Membrane bioreactors (MBR) are an alternative for improved removal of ARB and ARGs (Hiller et al., 2019). Due et al. (2015) reported more than 5 log units gene copies/100 mL reduction for tet and sul genes in an MBR with a pore size of 0.1 to 0.4 μm. Munir et al. (2011) showed a similar reduction in tet genes but a lower reduction in sul genes with 0.04 μm membranes. Kappell et al. (2018) and Cheng and Hong (2017) reported a 2.7 - 4 log reduction for tet, sul, and bla genes in an MBR with a pore size of 100 kDa - 0,3 μm. In another study, Munir et al. (2011) reported 1–3 log units gene copies/100 mL higher ARGs removal with MBR compared to conventional wastewater treatment. The same study reported 3 log abatement of tetracycline and 5 log abatement of sulfonamide resistant heterotrophic bacteria (CFU/100 mL). It is possible to remove more than 6 log units of non-resistant E. coli bacteria removal with MBR (Luca et al., 2013; Marti et al., 2011).

There is a limited number of publications about AMR removal efficiencies of membrane filtration methods (Hiller et al., 2019). Breazeal et al. (2013) reported up to 1 log unit gene copies/100 mL for bla_{TEM} gene removal with a pore size of 0.45 μm and 0.1 μm membranes, 1.7 log units removal with 100 kDa, 4.7 log units removal with 10 kDa, and more than 5.7 log units with 1 kDa membranes. Hence, ARG reduction with membrane systems strongly depends on the pore size of the membranes. Membranes have the potential as a barrier to ARGs (Böckelmann et al., 2009; Breazeal et al., 2013).

4. Conclusions

AMR causes more than 700,000 deaths each year, and this number is predicted to reach 10 million by 2050. ARB and ARGs end up in the urban water cycle through wastewater discharge or applications of manure and associated unintended run-off from agricultural land. Hence, ARG and ARB in the water sources and wastewater must be removed. In this work, a comprehensive literature survey was conducted to determine the AMR removal efficiency by membrane systems. Membrane filtration is one of the effective removal methods for AMR among wastewater treatment methods.

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