MEMBRANE TECHNOLGY FOR THE PREVENTION OF ANTIBIOTIC RESISTANCE IN WATERS

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German Society for Membrane Technology e.V.
(in German: Deutsche Gesellschaft für Membrantechnik e.V. – DGMT)
Working Group micro-pollutants
Universitätsstr. 2
45141 Essen

t : +49 (0)201.183-4299
e: info@dgmt.org
w: www.dgmt.org

Authors

Franziska Blauth (Institut für Energie- und Umwelttechnik e.V. (IUTA))
André Lerch (Technische Universität Dresden)
Ramona Osterloh (3M Deutschland GmbH)
Steffen Richter (Blue Foot Membranes GmbH)
Werner Ruppricht (MANN+HUMMEL Water & Fluid Solutions GmbH)
Winfried Schmidt

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01 DGMT SEES NEED TO ACT

On March 2 and 3, 2021, the German Society for Membrane Technology e.V. (in German: Deutsche Gesellschaft für Membrantechnik e.V. – DGMT) organized a stakeholder-dialogue focusing on the dissemination of multi-resistant bacteria via wastewater pathways. Many participants from different sectors of the water industry learnt about the current knowledge base and discussed the issues in detail. It is undisputed that wastewater and numerous processes in agriculture play an important role in the entry of multi-resistant bacteria into the environment [1]. A large number of studies illustrated that multi-resistant bacteria are already widespread in the environment. For example, antibiotic-resistant bacteria as well as antibiotic resistance genes, hereafter collectively referred to as resistances, have been detected in the effluent of various wastewater treatment plants. Within the HyReKA project, it was also demonstrated that the greater the influence of residential areas and the effluent volume discharged at the wastewater treatment plants, the higher their distribution in the waters [2].

The spread of resistances is of particular importance because of its persistence and ability to multiply, thus posing an increased health risk. It is estimated that by 2050 more people will die from infections with multi-resistant bacteria than from cancer [3]. At the same time, the willingness of pharmaceutical companies to develop new antibiotics and bring them to market is decreasing, as the ever-faster emergence of resistances means that it is no longer economically viable to develop new antibiotics [4].

The DGMT sees these developments as an opportunity to present suitable technical methods and processes to reduce or even prevent the spread of resistances via wastewater. Numerous studies have shown the potential of membrane technology in terms of effectiveness and efficiency, especially when used in combination with other processes, i.e. combined process of membrane filtration and adsorption on powdered active carbon. This can contribute significantly to solving the problem when combined with additional approaches (e.g., user behavior).

At present, so-called quaternary wastewater treatment for the elimination of micro-pollutants are planned or already built at numerous wastewater treatment plants. However, these are not, or are only partially, capable of preventing or reducing the spread of resistances, micro-pollutants, and microplastics into the environment. It seems reasonable, therefore, to include resistance removal in current planning for cost-efficient wastewater treatment.

This policy paper provides information on the above-mentioned issue in wastewater treatment as well as its effects and risks. It shows possible technical solutions that are available thanks to membrane technology. The aim is to generate social and political acceptance for more extensive wastewater treatment.

The DGMT would like to use this paper to address decisionmakers in politics, industry, environmental associations, and municipalities, who can contribute to solving the problem and taking appropriate action.

02 MEMBRANE TECHNOLOGY'S CONTRIBUTION TO RESISTANCE ELIMINATION

Membrane separation technology involves the retention of insoluble substances and, depending on the type of membrane, dissolved substances in water by using separating layers for filtration. Membranes are particularly suitable for the retention of bacteria, viruses, and bacterial components (plasmids, proteins, DNA fragments). The different application areas depend on the membrane's pore size and respective separation limit.

For several decades, membranes have been the state of the art filtration solution in various industries for the retention of bacteria and viruses. For example, membranes are used for the sterile filtration of liquid foods (i.e., beer, wine, fruit juice, dairy products). They are also used for sterilization in many processes in the pharmaceutical industry. Membranes have, for decades now, been used successfully for the separation of turbidity, bacteria, and viruses in the treatment of drinking water, e.g., spring, ground and surface water.

In municipal wastewater treatment, membrane bioreactors (MBR) are a proven technology and have been established in wastewater treatment plants for decades. In this application, the membrane retains the biomass (bacteria) used for wastewater treatment and produces a treated wastewater flow that meets the safety requirements for inland water quality according to Directive 2006/7/EC (Bathing Water Directive, [5]). In addition to the bacteria, resistances are also retained during this process. While conventional wastewater treatment plants have a removal capacity of approximately 3.5 log removal stages, MBR plants have up to 7 log removal stages (cf. Figure 1 and Figure 2).

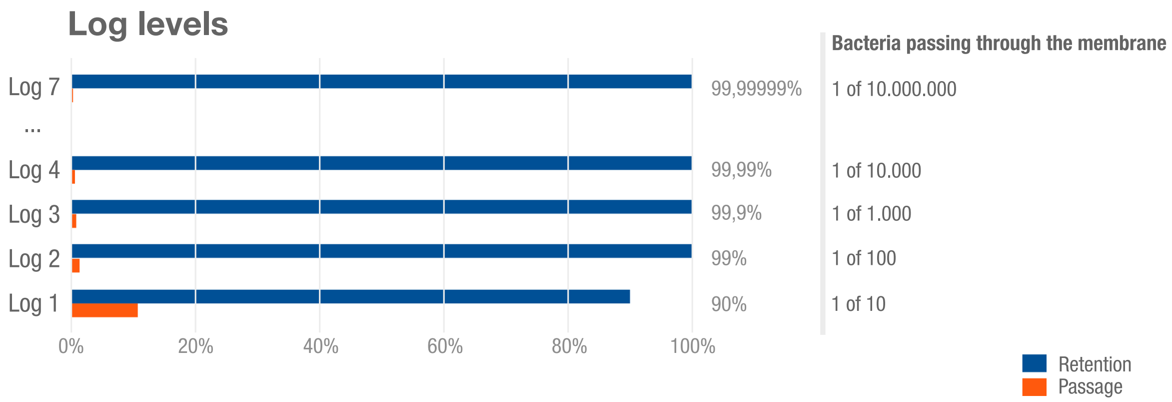

Fig. 1: Retention of bacteria in log levels. A log level describes the retention by a power of ten. Log 1 therefore describes a reduction of 90% bacteria

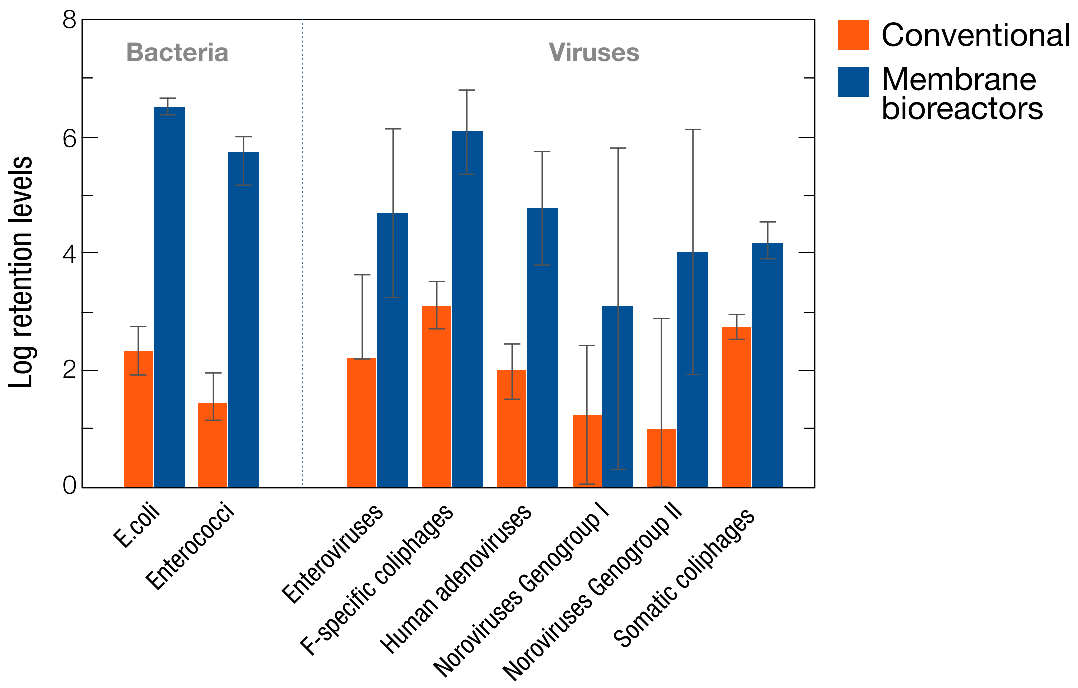

Abb. 2: Comparison of conventional activated sludge processes and membrane bioreactors with regard to the removal of typical bacteria and viruses (compiled literature data from [6]).)

In addition, the use of membranes in combination with other processes for micropollutants elimination, e.g., oxidation in combination with ceramic membranes or the use of powdered activated carbon in MBR plants, has received positive evaluations in several projects and references. In combination with membrane technology, the quaternary wastewater treatment can be further extended to include the retention of resistances.

This means that membrane technology can enable the retention of resistances from water using various process engineering variants. Its barrier effect reduces entry into the environment, thus minimizing the potential risk of an uncontrolled spread of the resistances.

03 RELEVANT ENTRY PATHWAYS FOR RESISTANCES

There are multiple possible input pathways for resistances into the environment:

- municipal wastewater with and without wastewater from hospitals,
- pharmaceutical industry wastewater,
- agriculture wastewater / liquid manure,
- slaughterhouse wastewater,
- landscape or agricultural utilization of biosolids.

Municipal and industrial wastewater are of particular interest to the DGMT. The contamination of wastewater from different sources with resistances has been proven in many studies. In Germany, the joint projects of the BMBF funding program RiSKWa [7], the HyReka project [8] and the ANTIRES project [9] are particularly worth mentioning.

Wastewater from hospitals and similar facilities is contaminated with a higher concentration of antibiotic resistances. These resistances are in part due to the use of antibiotics and are found in patient excretion. Due to the relatively high concentrations of these antibiotics (micropollutants) in hospital wastewater, new resistances can also be formed in the wastewater.

Treatment of hospital wastewater in conventional wastewater treatment plants does not provide the required hygienic reduction of resistances, as the plants are generally not designed for this. High concentrations of resistances in hospital wastewater also deliver correspondingly higher concentrations in the effluent of the wastewater treatment plants. This observation was confirmed in both the HyReka and ANTIRES projects, and the findings were confirmed in international projects [10]. Therefore, wastewater from hospitals and similar facilities can be described as a hot spot for the discharge of resistances into the environment.

Significant resistances can also be detected in municipal wastewater not contaminated by hospitals [11]. This is caused by the use of antibiotics in the domestic sector. Despite the fact that the content of antibiotics is about 25% lower than in hospital wastewater [12], municipal wastewater treatment plants should not be ignored when assessing discharge into the environment. In some cases, the number of certain resistance genes found in the plant's effluent was relatively higher than the plant's influent, even though this is not directly dependent on the antibiotic concentration [13]. Due to the large municipal wastewater volumes, the load plays an important role in the risk assessment.

04 CONCLUSION, FOOD FOR THOUGHT AND NECESSARY MEASURES

Resistances enter the environment via municipal and industrial wastewater treatment, which can lead to an increased health risk. This risk will further raise in the future due to the increasing accumulation and propagation of resistances in the environment. For this reason, the DGMT sees the need to broaden the discussion of this challenge socially, politically, as well as technologically, and to facilitate the discussion accordingly. The aim must be to prevent the spread of resistances via wastewater pathways as much as possible and to promote technologies such as membrane technology, which has already proven its suitability for the separation of bacteria, viruses, genes and particles in other areas, as a suitable approach.

The DGMT therefore considers it imperative:

1. to expand the social and political debate on micro-pollutants and microplastics in wastewater to include the topic of resistances, in order to increase societal awareness of this new challenge and acceptance of appropriate measures,
2. to define legal requirements and limit values for resistant germs in the discharged treated wastewater into receiving waters (streams, rivers),
3. to present the use of membrane technology as an effective measure to prevent the spread of resistances via wastewater into the environment, and to bring it into the ongoing debate about possible solutions,
4. to continue to publicly support projects with membrane processes, also as hybrid processes for the further elimination of micro-pollutants and micro-plastics (advanced wastewater treatment) from wastewater. Key projects should focus on wastewater treatment plants that discharge into small receiving waters or bathing waters.

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