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Membrane-based micropollutant removal

Mechanistic understanding

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Motivation

Recently, the number of potentially hazardous micropollutants (MPs) in surface water has increased as a result of the economic activity and the usage of pharmaceuticals and other substances in society. These organic compounds raise concerns about human health [1]; therefore, achieving efficient removal of MPs from surface water is crucial for the production of safe drinking water.

In this project, we aim to develop a comprehensive physical-chemical model for micropollutant (MP) removal using nanofiltration (NF) and reverse osmosis (RO) systems. The model will provide a better understanding and contribute to the design of membrane-based processes for water treatment.

Technological challenge

Membrane-based technology for MP removal has already been implemented in the production of drinking water [2]. However, the retention of MPs and transport through membranes is only poorly understood.

Developing a model to evaluate the performance of MP removal by membrane-based processes is a challenge because of the various compounds that might be found in water, and their differences in physicochemical properties, e.g., size, charge, structure, and functional groups.

Moreover, a model should include different transport mechanisms and physicochemical interactions depending on the properties of the compounds, the solution, and the membrane [3]. Hence, a first step is to create a MP classification based on molecular properties (see Fig. 1).

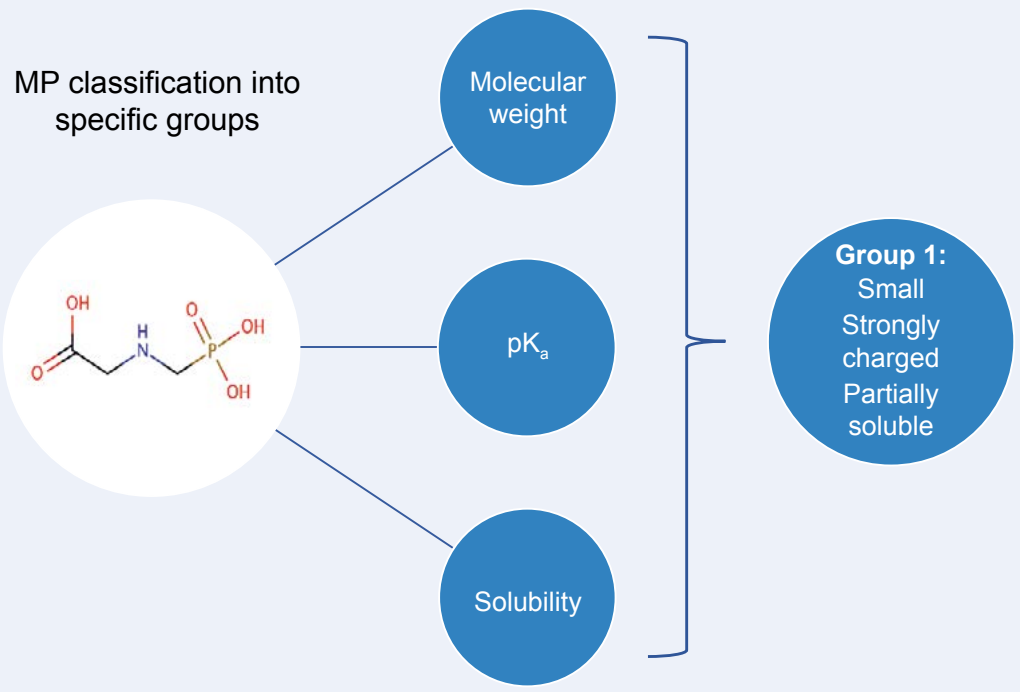

Fig. 1: Classification of glyphosate based on molecular weight (MW), solubility, and pKa. Similarly, based on these properties we can classify other MPs into different groups.

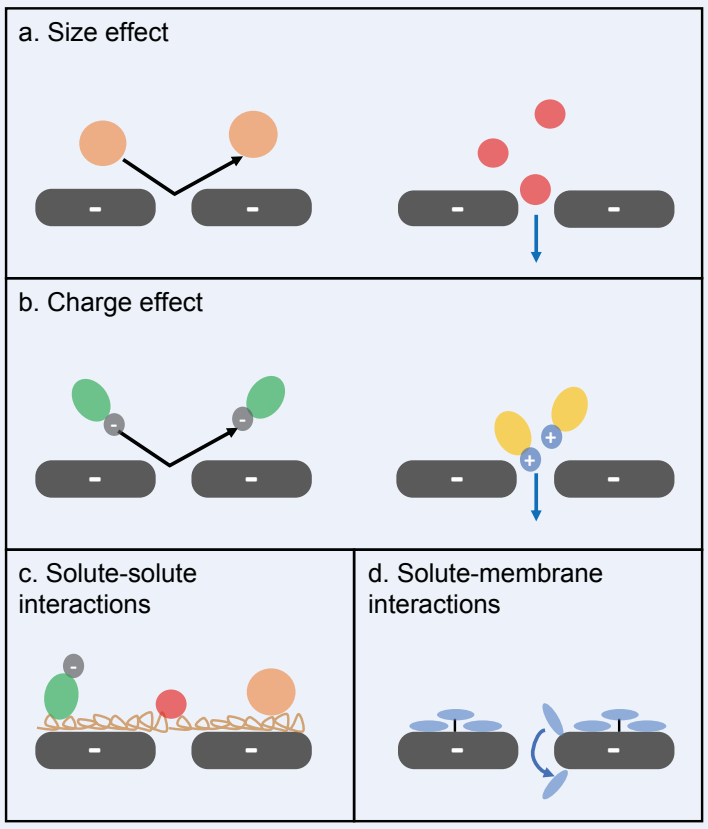

Fig. 2: Mechanisms and interactions involved in the removal of MPs: a) size sieving effect, b) charge attraction or repulsion, c) layer formation and interaction with MPs, and d) MPs-membrane interaction, e.g., adsorption and hydrophobic interactions.

Research goals

In this project, we will develop a robust theoretical framework based on physicochemical principles for MP removal with NF/RO membranes. We will study the solution/membrane interface and the transport through the membrane, and consider the effect of particular phenomena, e.g., aggregation of MPs and charge regulation.

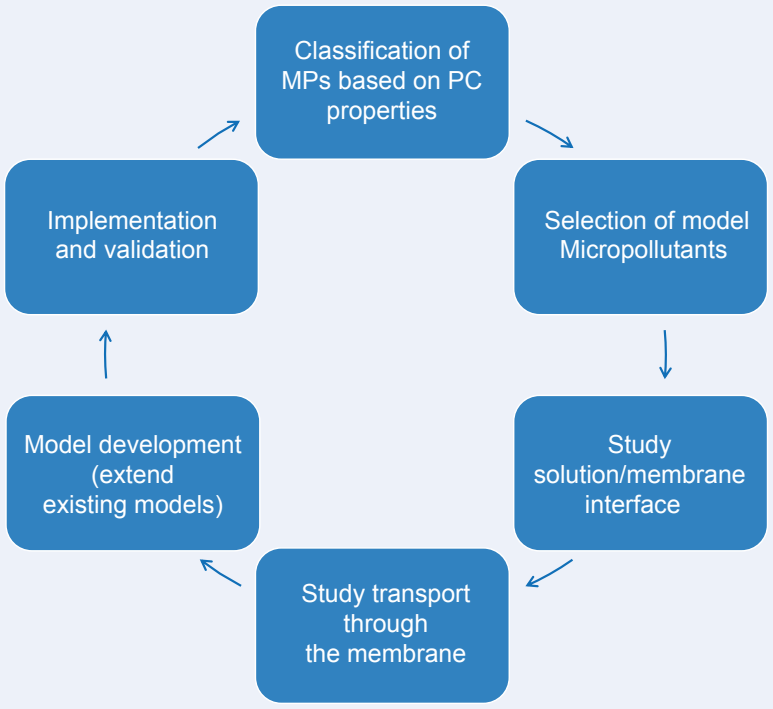

Fig. 3: Overview of the project methodology, PC: physicochemical.

References

[1] Schwarzenbach, R. P., et al. Science. 313, 1072-1077 (2006).
[2] Ojajuni, O., Saroj, D., Cavalli, G. Environ Technol Rev. 4,17-37 (2015).
[3] Khanzada, N.K., Farid, M.U., Kharraz, J.A., et al. J Memb Sci. 598, 117672 (2020).

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