

Permeability assessment of silicone membranes for gas tracers in aquatic environments.

ALEXANDRA K LIGHTFOOT¹, THÉO BLANC^{2,3},
MORGAN PEEL^{2,3} AND ROLF KIPFER³

¹ETH Zürich

²Université de Neuchâtel

³Eawag, Swiss Federal Institute of Aquatic Science and Technology

Inert gases, when introduced purposely as tracers in aquatic environments, serve as versatile tools for investigating phenomena such as groundwater dynamics, pollutant dispersion, and biogeochemical changes. More traditionally, bubbling has been used for rapid tracer dissolution; however, this technique can lead to significant gas loss and spatial heterogeneity in the water volume, whereby some portions of the water become highly saturated while other parts remain undersaturated. In contrast, diffusive dissolution of the tracer gas via silicone membranes ensures a more uniform distribution of the introduced tracer gas while conserving costly or scarce tracers.

This study examines the permeability of two silicone tube membranes for common gas tracers frequently applied in aquatic environments: helium, argon, krypton, xenon, and propane - with the aim of improving experimental setups and planning for future studies in-field. Permeability was assessed under gaseous and aqueous conditions by filling the silicone tube with the tracer gas and recording the internal pressure decay first with air as the external medium and then with water. The pressure drop inside the silicone tubing was measured from approximately 3 - 0.8 atm, as gas diffused through the membrane. From the pressure data, model fitting of two distinct regimes was necessary: an exponential decay in the high-pressure region (> 1.5 - 2 atm) and a linear decay in the low-pressure region. Our initial results indicate that the silicone membranes exhibit higher permeability for heavier gases, both within the low- and high-pressure regions.

The permeability for CO₂ was additionally determined for the two silicone tubes - although not typically utilised as a tracer, its inclusion was motivated due to the significant role it plays in current carbon capture projects. These insights provide a foundation for optimizing the selection of tracers in groundwater and aquifer studies for future experiments.