EFFECT OF WATER COMPOSITION ON PERCLORATE REMOVAL FROM POLLUTED GROUNDWATER USING ION EXCHANGE MEMBRANE BIOREACTOR

Alon Zelichover, Zuckerberg Institute for Water Research, Ben Gurion University of the Negev
Alonzeli@post.bgu.ac.il
Shalom Fox, Zuckerberg Institute for Water Research, Ben Gurion University of the Negev
Zeev Ronen, Zuckerberg Institute for Water Research, Ben Gurion University of the Negev
Yoram Oren, Zuckerberg Institute for Water Research, Ben Gurion University of the Negev
Jack Gilron, Zuckerberg Institute for Water Research, Ben Gurion University of the Negev

Key Words: Perchlorate, Ion exchange membrane, Bioreactor; Donnan dialysis, Groundwater treatment

Perchlorate contamination of ground water is a worldwide concern. At several sites in Israel's coastal aquifer, hundreds of ppm of perchlorate was found accompanied with significant concentrations of nitrate and chlorate, consequently preventing water production from wells in the area. The IEMB hybrid process [1] allows safe treatment of high perchlorate (and nitrate and chlorate) contaminated groundwater. The Donnan dialysis process removes the perchlorate from the water compartment using an anion exchange membrane (AEM) to the bio-compartment where it undergoes microbial degradation to much safer components such as chloride. The AEM acts as a barrier and keeps both compartments completely separate. Glycerol is used as an exogenous carbon and electron source for the biodegradation process [2]. This arrangement keeps the carbon source, reaction byproducts and bacteria confined in the bio-reactor thus preventing the contamination of the treated water. The present study examines the performance of the IEMB in removing perchlorate and other anions (nitrate and chlorate) at levels of hundreds mg L^{-1} from polluted ground water from the Ramat HaSharon (RHGW) contaminated site. The IEMB removal of the polluting anions was studied initially for synthetic and actual ground water fed to the water side while feeding 0.1 N of NaCl to the bio-compartment. We further studied the effect of adding bacteria and bio-media to the bio-compartment. In all experiment setups it is obvious that perchlorate dominates the flux across the AEM. Even though perchlorate concentration is considerably lower than nitrate and chlorate, its flux is greater than the sum of the other anion fluxes. At an effective driving force (EDF) value above 0.7 [mM] perchlorate had a negative effect on the other anions transport across the membrane. Adding bacteria to bio-compartment side fed with RHGW and bio-media increased anions total flux by 15%-23% at the first two runs. A thick biofilm has developed on the membrane bio-side during the following two runs, resulting in a total flux decline of 18%-22% when compared to the pure Donnan dialysis experiment. Throughout all the bio-degradation experiment regardless of the anion load to the bio-compartment the bio-degradation efficiency of the trace anions was above 99%. This study is the first to treat highly polluted complex ground water in an IEMB. It further established the perchlorate strong interaction with the AEM, consequently affecting the flux of other anions in the treatment process. This research is the basis for upscaling the IEMB technology into the field.

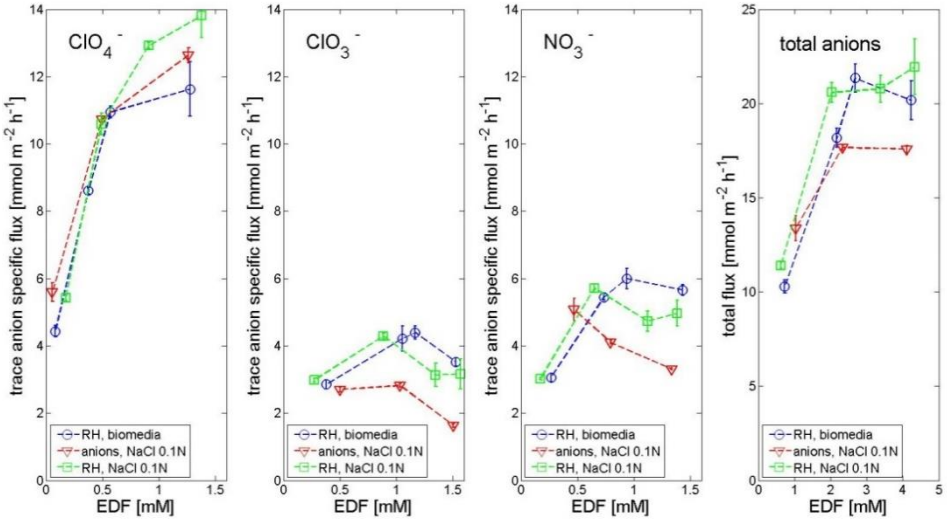

Figure 1 – Trace anions specific flux vs. the Effective Driving Force (EDF) of perchlorate, chlorate, nitrate and anions total flux vs. the total EDF, for IEMB Donnan dialysis experiments fed with (o) RHGW and bio media, (▽) synthetic anions solution and NaCl 0.1N and RHGW and NaCl 0.1N (□) into the water compartment and bio-compartment, respectively.

[1] A.D. Fonseca, J.G. Crespo, J.S. Almeida, M.A. Reis, Drinking water denitrification using a novel ion-exchange membrane bioreactor, Environ. Sci. Technol. 34 (2000) 1557–1562.
[2] S. Fox, Y. Oren, Z. Ronen, J. Gilron, Ion exchange membrane bioreactor for treating groundwater contaminated with high perchlorate concentrations., J. Hazard. Mater. 264 (2014) 552–9.