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Zn transport and fate in sand columns containing microbial biofilms

Suyin Yang, Bryne Ngwenya, Ian Butler, and Stephen Elphick
School of Geosciences, Earth Subsurface Research Group, Grant Institute, University of Edinburgh, UK
(suyin.yang@ed.ac.uk)

Both biofilms and trace metals are ubiquitous in subsurface and aquatic system. Their interactions are of great interest. The growth of biofilms results in the decrease of porosity, hydraulic conductivity and flow rate and therefore retards metal transport in porous media. Biofilms mainly consist of extracellular polymeric substance (EPS), immobile bacteria and mobile bacteria. EPS compounds and bacteria cell wall contain acidic functional groups that when deprotonated, can bind significant concentrations of metal cations. With the migration of mobile bacteria, the transport of metal adsorbed to bacteria might be facilitated. Metals, in turn, affect microbial growth both as nutrients and toxins. The toxicity may increase the detachment of bacteria leading to facilitated metal transport or increasing the EPS production resulting in retardation of metal transport. In this study, we aim to investigate the interactions between metal and biofilms, especially, the effect of biofilms on zinc transport and fate in porous media.

Batch experiments were performed to assess Zn adsorption onto bacterium strain *Pantoea Agglomerans*. Voltammetry with solid-state gold-amalgam microelectrodes was tested and used to analyze labile zinc in cell suspensions. Then, polycarbonate column packed with sand was set up to test the effect of biofilm on Zn transport and the impact of Zn on biofilm growth. *P. agglomerans* cells were inoculated to develop a biofilm for one week with the supply of nutrient broth medium. Hydraulic conductivities were continuously measured while cell viable was monitored from column outflow by colony forming units. Inductively coupled plasma atomic emission spectrometry was used to quantify total zinc in solution and biofilms.

Our batch experiments showed adsorption of Zn in bacteria and suggest that voltammetry with solid-state electrodes is suitable to quickly and effectively quantify labile zinc in solution and consequently to derive surface complexation constants for metals and bacterial surfaces. The breakthrough curves in our continuous flow column experiments show both facilitated and retarded Zn transport within one week of biofilm growth, dependent upon the aqueous Zn concentration. With higher concentration of Zn, the mobility of the detached bacteria and EPS enhanced Zn transport, due to metal toxicity. And after a 10 day period of running with Zn in the column, most of Zn accumulated in the bottom of the column where higher biofilm growth was detected. The results indicate a flexible modelling approach is necessary for quantifying metal contaminant transport in microbial biofilms.