Transport and transformations of roxasone and Gd-DTPA in soil under various redox conditions

ISHAI DROR*, ADI MENAHEM AND BRIAN BERKOWITZ

Department of Earth and Planetary Sciences, Weizmann Institute of Science, 7610001, Rehovot, Israel (*correspondence: ishai.dror@weizmann.ac.il)

We present the transport of two organometallic complexes, Gd-DTPA and roxarsone (As containing substance) and their metal salts ($Gd(NO_3)_3$, $AsNaO_2$), under varying redox states. Gd-DTPA is used widely as a contrasting agent for MRI, while roxarsone is applied extensively as a food additive in the broiler poultry industry. Studies have shown that the transport of organometallic complexes in groundwater is affected by environmental conditions such as redox states, pH, and soil type. In this study, column experiments using sand and Mediterranean red sandy clay soil were performed under several redox conditions: aerobic, nitrate-reducing, iron-reducing, sulfate-reducing, strong biologically-induced reducing, and strong chemically-induced reducing. Batch experiments to determine adsorption isotherms were also performed for roxarsone and metal salts. The AQUASIM software package was used to study physical properties of the porous media. We observed that the metal salts show essentially no transport while the respective pharmaceuticals display much faster breakthrough. We also found that Gd-DTPA transport was affected by the soil type and was not affected by the redox conditions. In contrast, roxarsone transport was affected mainly by the different redox conditions, showing delayed breakthrough curves as the conditions became more biologically reduced (strong chemically-induced reducing conditions did not affect the transport). We suggest a mechanism for the trend of roxarsone behavior that includes adsorptive retardation for aerobic and nitrate-reducing conditions, and a non-adsorptive mechanism for iron-reducing, sulfate-reducing and strong biologically-induced reducing conditions. We relate the delayed breakthrough behavior to the increasing microbial activity, which in turn promotes generation of lower redox potential and production of stronger reducing agents. The results suggest that Gd-DTPA is a stable complex, with potential for high mobility in groundwater systems, whereas roxarsone transport through groundwater systems is affected by redox environments, demonstrating high mobility under aerobic and nitrate-reducing conditions and delayed transport under iron-reducing, sulfate-reducing and strong biologically-induced reducing conditions.