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Microbially induced carbonate precipitation (MICP) by denitrification as ground improvement method - Process control in sand column experiments

Vinh Pham (1), Leon van Paassen (1), Akiko Nakano (2), Motohei Kanayama (2), and Timo Heimovaara (1)
(1) Department of GeoScience & Engineering, Delft University of Technology, Delft, The Netherlands (l.a.vanpaassen@tudelft.nl), (2) Faculty of Agriculture, Kyushu University, 6-10-1 Hakozaki, Higashi-ku, Fukuoka, Japan

Calcite precipitation induced by microbes has been proven to be efficient in stabilizing granular soils, especially with urea hydrolysis, as it has been successfully demonstrated in a pilot application 2010. However, as a byproduct highly concentrated ammonium chloride (NH4Cl) solution is produced, which has to be removed and disposed and forms a significant disadvantage of the technique that makes an alternative process like denitrification preferred. The proof of principle of microbially induced calcite precipitation (MICP) by denitrification has been demonstrated by Van Paassen et al (2010) who suggested that instead of producing waste as a byproduct, different pre-treated waste streams could be used as substrates for in situ growth of denitrifying bacteria and simultaneous cementation without producing waste to be removed. In this study sand column experiments are performed in which calcium carbonate was successfully precipitated by indigenous denitrifying micro-organisms, which were supplied weekly with a pulse of a substrate solution containing calcium acetate and calcium nitrate. Besides the production of calcite and the growth of bacteria in biofilms, the reduction of nitrate resulted in the production of (nitrogen) gas. It was observed that this gas partly fills up the pore space and consequently contributed to a reduction of the permeability of the treated sand. The presence of gas in the pore space affected the flow of the injected substrates and influenced to the distribution of calcium carbonate. The effect of the mean particle size (D50) on the flow and transport of solutes and gas in the porous media has been evaluated by treating several columns with varying grain size distribution and comparing the change in permeability after each incubation period and analyzing the distribution of the gas throughout the columns using X-ray computed tomography (CT) scanning. The present results show that there is a considerable decrease of permeability – a reduction factor of up to 18 - for the sand with a mean particle size of 0.1mm. The coarser sand with a D50 of 0.25 mm resulted in a lower permeability reduction. The observed permeability reduction and the images of the CT scans improve the understanding of the biochemical process inside the porous media at column scale and will aid the scale up of this process to commercial application.