Formation processes and prevention strategies of scale deposits in tunnel drainage systems

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Calcium carbonate scale deposits ($CaCO_3$ mineral precipitation from aqueous solution) in drainage systems and water circuits are a common and challenging issue, especially if deposition and clogging limit the water flow. Maintenance work including various mechanical removal of the unwanted mineral deposits causes high costs and major traffic disturbances. This argues for an optimized case-specific process understanding regarding variable scale material characteristics, sedimentary dynamics, its environmental control and sustainable prevention strategies. Geogenic presetting, such as the chemical composition of local groundwater and (hydro)geological framework, as well as technical-operative conditions, such as interaction with cementbound building materials, the drainage design (flow geometries) or the use of chemical additives (inhibitors), affect the specific formation mechanisms and consequently the appearance, composition and consistency of the scale deposits. Microbes such as chemolithoautotrophic bacteria can significantly influence scaling reactions and should also be evaluated in the case-specific prevention strategies. The eco-friendly inhibitor polyaspartate (PASP) was tested and assessed in order to reduce and modify the amount, consistency and (micro)structure of the predominant $CaCO_3$ scale deposits. Dosage of small amounts of PASP results in (i) a substantial inhibition of $CaCO_3$ formation, (ii) a more porous or even loose scale consistency (calcareous mud), and (iii) a shift in $CaCO_3$ mineralogy from predominant calcite toward vaterite. A few parts per million of PASP can induce a saturation index in respect to calcite of about 2, i.e. close to the saturation level of amorphous calcium carbonate (ACC). The research activities presented combine-promising results with regard to fundamental carbonate research as well as practical technical solutions in the context of tunnel maintenance.