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Ecological engineering to control bioclogging: an original field study coupling infiltration and biological measurements

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Infiltration systems are increasingly used in urban areas for several purposes such as flood prevention and groundwater recharge. However, their functioning is often impacted by clogging that leads to decreases in hydraulic and water treatment performances. These systems are commonly built with sand as infiltration medium, a media subject to rapid clogging by the combined and overlapping processes of pore occlusion by fine particles and biofilm development. In a previous study, we pointed out that the phototrophic component of biofilms developed at the surface layer of infiltration systems (algae, cyanobacteria) could reduce by up to 60-fold the saturated hydraulic conductivity. Consequently, it appears crucial to control biofilm growth to maintain porous infiltration media performances. The present study aimed to test the influence of biotic (addition of animals or macrophytes) and abiotic (light reduction) treatments on biofilm development and associated hydraulic properties in an infiltration device dedicated to aquifer recharge with river water in Lyon Area (France).

Twenty-five benthic enclosures were used to test 5 "treatments" on non-manipulated surface layer under field conditions. Three biotic treatments consisted in the introduction of: (i) an invertebrate acting as algae grazer (Viviparus viviparus), (ii) an invertebrate that digs galleries in sediments (Tubifex tubifex), and (iii) a macrophyte that could inhibit benthic biofilm by allelopathic activity (Vallisneria spiralis L). The fourth treatment was designed to simulate shading. The last "treatment" was a control which monitored the evolution of the system during the experiment without manipulation (addition of macro-organisms or shading). Each treatment was replicated five times. The experiment was conducted for 6 weeks, and sampling of the surface layer (0-1 cm) was carried out in each enclosure at the beginning (t0) and the end (tf). We coupled biological characterizations (organic matter, algal biomass, bacterial abundances, microbial enzymatic activities, EPS composition, and photosynthetic efficiency) with in situ hydraulic conductivity measurements (falling head method, five measures per enclosure at t0 and tf). Our results showed that some treatments could regulate benthic biofilm growth and improve infiltration rate. For instance, V. viviparus treatment resulted in a decrease in chlorophyll-a, EPS sugar and protein contents and an associated increase of infiltration rate, while it decreased in the control treatment. These results are very promising for the future development of ecological engineering solutions to prevent biological clogging in systems dedicated to infiltration. To our knowledge, this study is the first to highlight such potential role of macro-organisms under field conditions.