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Experimental analysis at the meter scale of denitrifying woodchips bioreactor performance under variable loading conditions

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The excessive use of fertilizers in conjunction with agricultural tile drainage can lead to high levels of nitrate (NO_3) in subsurface waters, which can pollute rivers, eventually causing eutrophication of larger water bodies. Among several water treatment alternatives, biological denitrification in edge-of-field woodchip bioreactors represents a popular option, given its relatively easy implementation, minimal maintenance and low cost. Since microbial denitrification is commonly catalyzed by facultative heterotrophic bacteria in anoxic environments, oxygen concentration is a key parameter to keep in consideration. To monitor dissolved oxygen concentration inside the test bioreactor in a non-invasive manner, oxygen optode sensors are used. Bioreactor performance also depends on several other factors, including hydraulic residence time, influent nitrate concentrations, and woodchips flow and transport parameters. One particular aspect that has been overlooked in the literature is how gas generation due to bacterial respiration can hinder the water flow through the bioreactor, hence reducing its effective porosity and denitrification performance. A continuous monitoring of inlet and outlet flow rates is applied to detect flow fluctuations during the experiments. Given the uncertainty and challenges associated with field observations, meter-scale experiments conducted under controlled boundary conditions and known porous media distribution represent a convenient method for studying the influence of water quality and hydraulic parameters on nitrate removal. The aim of this work is to characterize the bioreactor performance using woodchips with different particle sizes and to investigate the effect of retention time and inlet NO_3 concentration on NO_3 removal under variable flow conditions. For this purpose, a series of experiments are conducted in a $147.7 \times 10 \times 38.5\ cm^3$ flume under well-controlled laboratory conditions.