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Laboratory investigation of hydraulic and chemical behavior of woodchips to better understand performance of denitrifying bioreactors

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Microbial conversion of nitrate (NO_3-) into gaseous nitrogen (N2), also known as denitrification, is facilitated by high organic carbon soil content. Under saturated conditions, denitrifying woodchip bioreactors have the ability to reduce the agricultural load of nitrate into the environment, tackling the rising problem of eutrophication of natural water bodies. Bioreactor performance depends on several factors, including loading flow rates, influent nitrate concentrations, dissolved oxygen concentrations, water temperature, and woodchips flow and transport parameters. The residence time of water is one key factor controlling the efficiency of denitrification. When residence time is too short, contact time with denitrifying bacteria can be insufficient for nitrate to be completely removed from inflowing water and microbial activity can lead to the production of greenhouse gases like carbon dioxide, nitrous oxide, and methane. Another key parameter affecting nitrate removal rates is the size of woodchips, which correlates to the specific surface area of the porous medium. The aim of this work is to characterize the chemical behavior of woodchips with different particle size distributions and to investigate the effect of retention time on NO_3- removal under variable flow conditions and temperature. For this purpose, a series of cm-to-m 1D-column experiments and quasi-2D flume experiments are conducted under well-controlled laboratory conditions.