Biological nitrate removal in a laboratory-scale slow sand filter

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Abstract

This research evaluated removal of nitrates from drinking waters in a slow sand filter (SSF). Batch experiments were performed to determine optimum carbon to NO_3-N (C/N) ratio for the filtration experiments. The filter column was filled with filter sand of an effective diameter of 0.5 mm and uniformity coefficient of 1.23. The filter was operated at filtration rates of between 0.02 to 0.120 m/h and 0.01 to 0.25 m/h with concentrations of 22.6 and 45.2 mg NO_3-N/ℓ, respectively, and effluent samples of the SSF were taken at 6 depths of 10, 15, 20, 40, 60, 80 cm, and the bottom. Optimum C/N ratio was found to be 1.5 when using ethanol in batch tests when the removal efficiencies of NO_3-N and C were higher than 90%. Although increasing filtration rates decreased NO_3-N removal, effluent NO_3-N concentration at the effluent port of the SSF was lower than the limit value. Most of the NO_3-N removal was carried out at the upper layer of (10 cm) the filter bed. Concentration of NO_3-N, NO_2-N, and C were not detected at the 60 cm depth of the SSF through the study for the inlet concentrations of 22.6 mg NO_3-N/ℓ. As expected, increasing influent NO_3-N concentration to 45.2 mg/ℓ increased NO_3-N, NO_2-N, and C concentrations in the effluent water. The SSF process was unable to provide NO_3-N removal rate of more than 228 g $N/m^3 \cdot d$ (0.2 m/h flow rate, 217g $N/m^2 \cdot d$ of surface loading rate). The NO_3-N removal efficiency dropped slightly from 96 to 95% when the loading rate increased from 228 to 285 g/$m^3 \cdot d$, but the effluent water contained higher concentrations of NO_2-N (8.4 mg/ℓ) than the standard value. The results of the SSF experiment demonstrated that averaged nitrogen conversion to volatile solids was about 0.77 mg VS/mg NO_3-N.

Keywords: biodenitrification, slow sand filtration, drinking water