Removal of nitrate from drainage water using wood chips

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The nitrogen concentration in Dutch surface water is too high on many places. Leaching of nitrate from agricultural land is a major source of nitrogen in surface waters. With current fertilizer policy the water quality standards included in the Water Framework Directive cannot be met on short term. To meet these requirements, additional measures are therefore needed to reduce nitrate leaching from agricultural soils in the short term.
By denitrification nitrate can be converted into nitrogen: $NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$. For this process, organic matter is needed as an electron donor. On about 50% of Dutch farmland water is discharged to surface water via drainage pipes. By placing a filter with organic matter at the end of the drainage pipe the leached nitrate is converted to gaseous N_2. For this purpose woodchips are often studied currently, since they are relatively stable on a longer term. In a column experiment we studied nitrate removal from a solution containing 100 mg/L NO_3^-. In the column we used woodchips from softwood and hardwood, either pure or mixed with sand (1:1 volume ratio). Residence time was either 3.6 days (slow) or 1.7 days (fast). The P concentration in the effluent and N_2O-emission were determined frequently.

Experimental results show that 100% of the nitrate in the water could be removed in the columns. The extent of removal depends on the type of woodchips and on the residence time of water in the filter: hardwood removed more than softwood; mixing with sand decreased removal; increasing retention time of the water increased removal rate.

A practical problem is that a few days are needed to remove all nitrate from the water. Therefore, for drainage flows expected in practice, the filter must be too large for placing at the end of a drainpipe.

There is also a risk of 'pollution swapping': while nitrate is removed, there may be losses in the form of nitrous oxide (N_2O) and phosphate. Emission of N_2O differed between treatments: hardwood emitted much more than softwood; mixing with sand increased emission; increasing retention time of the water reduced emission. Concentrations of P-tot in the effluents were above the Dutch standard of 0.15 mg total P L-1 during 3 months. With hardwood P-tot started above 40 mg P-tot L-1, and decreased thereafter; softwood started low and increased to 0.6 mg P-tot L-1 thereafter.

We concluded that potential pollution swapping by N_2O emission and phosphorus leaching should receive more attention when nitrate removal with organic matter is considered.