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Denitrification coupled to pyrite oxidation and implications for groundwater quality: a case study (Oostrum, the Netherlands)

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Denitrification is the major pathway of nitrate removal from groundwater systems, with organic matter or minerals, primarily pyrite, serving as electron donor. Although the reaction with organic carbon is thermodynamically favored, denitrification coupled to pyrite oxidation has been proposed to be the dominant process in a number of field studies (e.g. Postma et al., 1991, *Water Resources Research* 27: 2027-2045). Because pyrite oxidation causes an increase in the sulfate concentration, as well as the release of trace metals and changes in pH, it can significantly affect groundwater quality. This study focuses on the occurrence and effects of denitrification at Oostrum, the Netherlands, where shallow groundwater exhibits high nitrate levels (up to 500 mg/L) due to intense fertilizer application. We compare groundwater compositions measured in 1996 and 2006 in wells located in cultivated fields and in a downstream forested area. In the agricultural area, nitrate removal from the groundwater correlates with sulfate production and the release of trace metals plus Fe^{2+}. Together with the presence of pyrite in the sediment matrix, these results point to denitrification coupled to pyrite oxidation as the main pathway removing nitrate infiltrating into the aquifer. The compositional trends measured in 1996 and 2006 under the cultivated fields are similar, although the nitrate concentrations dropped by about 20% over the 10-year period, reflecting decreased fertilizer use. In contrast, in the forested area the concentrations of pollutants (nitrate, chloride and trace metals) have risen since 1996, as a result of contaminated groundwater flow originating from the agricultural area.