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Short communication

Denitrification of groundwater using Brewer's spent grain as biofilter media

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abstract

This study evaluated Brewer's spent grain as media for denitrification processes in treating groundwater. A laboratory scale reactor was inoculated with anaerobic sludge from a waste-water treatment plant. Optimization of running conditions were investigated under various parameters including: hydraulic retention time (HRT), influent nitrate loading and pH. The experimental results demonstrate that the optimum reaction parameters were: HRT = 100 min; N-NO_3 = 200 mg L^{-1}; pH = 7.5–7.9. Vertical study showed that hydraulic retention time and pH affect significantly the nitrate removal, while nitrate loading do not affect the denitrification process.

1. Introduction

The content in nitrate of the underground and surface waters is in continual increase these last years with the intensification of agriculture, the industrialization and the urbanization. About 30–70% of the fertilizing nitrogenous used in agriculture is lost in the environment as nitrates that one recovers in the surface and underground waters (Li et al., 2003). And yet, these waters are exploited for the drinking water in most countries in the world, (Alabdula'Aly Abdulrahman, 1997). At elevated concentra- tions, nitrate consumption causes methemoglobinemia in infants (Blue-Baby) and nitrate is reduced to nitrite in the intestine which has been said to be linked to several cancers (Cheikh et al., 2013). Furthermore, nitrosamines are carcinogenic compounds that may be formed from nitrite in stomach (Gomez et al., 2000). Also, increased reactive N can have lasting adverse ecological effects contributing to eutrophication, hypoxia, toxic algal blooms, shifts in the food chain, loss of biodiversity, loss of fish stocks and habitat degradation in streams, lakes and coastal waters and elevated N_2O emissions (Galloway et al., 2003; Warneke et al., 2011). To limit nitrate and nitrite concentrations in drinking water, the World Health Organization (WHO) legislation limits the maximum concentration of nitrates to 45 mg L^{-1} without nitrites (Feleke and Sakakibara, 2002).

There is a need to develop simple, low-cost treatment systems (both in terms of construction and ongoing maintenance) to remove NO_3^- from effluents and from point source discharges from drained agricultural land (Schipper et al., 2010).

A number of nitrates removal processes have been developed which can be chemical (chemical reduction), physical (reverse osmosis, electro dialysis), chemical–physical (ion exchange) or biological. Among these, only ion exchange and biological denitrification are feasible on a large scale.

Furthermore, the biological process is the most environmentally sound as nitrate is completely eliminated (Mateju et al., 1992). Denitrification is a microbial process that mitigates nitrate-N pollution by reducing nitrate-N to N_2 or N_2O in hypoxic conditions utilizing an electron donor such as organic carbon (Casey and Mark, 2012).

Denitrifying bacteria are ubiquitous in nature (Zumft, 1997; Watmough et al., 1999; Bothe et al., 2000), and biological denitrification treatment consists of the provision of suitable carbon and energy sources which may be organic or inorganic compounds (Peng et al., 2007).

Numerous studies have investigated the denitrification of drinking water, residential wastewater, and agricultural runoff testing agricultural and wood by-products as structured biofilter media. Results from studies by Soarcs and Abeliovich (1998) and Aslan and Turkman (2003) indicate that wheat straw can be used as biofilter media and as a carbon source for the denitrification of drinking water.

Lowengart et al. (1993) also used wheat straw to denitrify turbid and nitrogen-rich irrigation water. Similarly, Blowes et al. (1994) have demonstrated that wood chips can be used to as a

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