

Denitrification of drinking water - A bioenergetic evaluation

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Abstract

An investigation into denitrification of groundwater, using fluidised bed reactors with ethanol as carbon source and electron donor included, *inter alia*, determination of the bioyield and the ethanol to NO₃ ratio required to effect complete denitrification. The values measured for these parameters are in close agreement with other published data. Y_{rac} equals 0.15 g cells/g NO₃ metabolised or 0.3 g cells/g ethanol metabolised, and the g ethanol utilised/g NO₃ removed is 0.5. However, theoretical investigation into the denitrification process indicates that the observed yield data are very much lower than those expected from theoretical considerations, i.e. an approximate expected theoretical anoxic yield of 0.69 g cells/g ethanol metabolised.

To investigate possible reasons for the discrepancy, a bioenergetic model was formulated. Application of the model to anoxic processes using reasonable assumptions based on expected anabolic and catabolic efficiencies also gives theoretical yield data which are much higher than those obtained experimentally here and in other published data. To obtain agreement between theory and practice the catabolic efficiency has to be reduced to approximately one third of its expected value. Possible reasons for this discrepancy are proposed.

Introduction

Groundwater denitrification using fluidised bed (FB) reactors with ethanol as carbon source and electron donor, was studied at the Technion, Haifa, Israel. The experimental system and operating results regarding denitrification efficiency, NO₃ and NO₂ profiles, biomass profile and physical characteristics of the biofilm are given elsewhere (Green et al., 1993; 1994). This paper concentrates on the experimental results for both bioyield and the corresponding C and N removals and their relation to theoretical expectations which are based on bioenergetic considerations.

Experimental work

Material and methods

Reactors

FB reactors with a working volume of 8.91 (9 cm dia.) were used for the denitrification experiments. A constant temperature of 25°C was maintained.

Feeding solution

The reactors were fed with tap water enriched with NO₃ (100 mg/l as NO₃), ethanol (50 to 100 mg/l) and phosphate (1 mg/0-

Analysis

Nitrate was measured using the spectrophotometric screening method, according to *Standard Methods* (1989). Nitrite was analysed by the colorimetric method according to *Standard Methods* (1989) and ethanol was determined using an enzymatic method (Sigma kit). The total and volatile suspended solids (TSS and VSS) concentration was measured according to *Standard Methods* (1989). VSS was used as the measure for biomass concentration.

Sampling procedure

A short tube with a measured volume of 5.4 ml together with the accompanying valves were connected to the sampling ports. Reactor contents from a given sampling port height were released through the tube and subsequently trapped for measurement.

Excess biomass removal

Excess biomass was taken out manually once or twice a day (depending on the volumetric loading rate in the reactor), by draining from the reactor the portion of the biofilm-covered sand above a desired level. Stripping of the biomass from sand particles was performed by a high speed mixer and the clean sand was returned to the reactor.

Predominating bacteria

Pseudomonas spp. were found to be the dominating bacteria.

Results

Biomass yield

Biomass yield was determined at reactor operating conditions which gave almost zero nitrite and ethanol concentrations in the effluent (to ensure no ethanol by-product residuals). The biomass yield which is defined here as grams of cells produced per gram of NO₃ or ethanol removed, was calculated based on NO₃ and ethanol concentrations in the influent and effluent and on the biomass concentrations in the reactor and effluent (including biomass removal). The biomass concentration in the reactor was determined based on a weighted average of biomass concentrations along the reactor. The average biomass yield was found to be 0.15 g cells/g NO₃ removed and 0.3 g cells/g ethanol removed.

Ethanol requirement

Minimal ethanol requirement for NO₃ removal was studied at retention time of 4.5 min. Ethanol to NO₃ mass ratio was decreased

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