Geophysical Research Abstracts
Vol. 15, EGU2013-10475, 2013
EGU General Assembly 2013

Is pre-conditioning required for the measurement of in situ denitrification rates with push-pull 15N-tracer tests?

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Diffuse NO_3^- emissions derived from agricultural N surpluses are the main cause of NO_3^- pollution of aquifers and open water bodies. Denitrification is the key process for the attenuation of this anthropogenic NO_3^- in groundwater. Knowledge about the spatial variability denitrification rates in nitrate-contaminated aquifers is crucial to predict the development of groundwater quality. However, the spatial distribution and intensity of denitrification in aquifers is difficult to predict. But precisely this knowledge is important for an effective implementation of measures for the reduction of agricultural N-surpluses to gain a good chemical status of groundwater bodies.
Push-pull tests have proven to be a relatively low-cost instrument to obtain quantitative information about aquifer properties and microbial activities in aquifers. These tests have been already successfully used for the measurement of in situ denitrification rates (Dr(in situ); Well and Myrold, 2002;Konrad, 2007). We conducted 28 push-pull tracer tests in the Großen Kneten (GKA) and the Furberger Feld aquifer (FFA), two Pleistocene sandy aquifers in Lower Saxony (Germany) to measure Dr(in situ) and to derive an estimate on the stock of reactive compounds. In the deeper NO_3[U+203E]-free zone of the aquifer, Dr(in situ) was relatively low despite the high abundance of reductants. Our aim was to check whether pre-conditioning by repeated NO_3^--injections would stimulate indigenous denitrifiers and thus lead to increased reduction rates of NO_3[U+203E] corresponding to the stock of reductants.
Pre-conditioning by the injection of the electron acceptor NO_3[U+203E] prior to subsequent push-pull tracer tests with 15N labelled NO_3[U+203E] was performed at 4 depths in the NO_3[U+203E]-free groundwater zone in the Fuhrberger Feld aquifer. We compared unconditioned and pre-conditioned in situ denitrification rates with laboratory denitrification rates measured during one year laboratory incubations with corresponding aquifer material (Dr(365)).
Our results show that Dr(in situ) measured after pre-conditioning of push-pull injection points (67.83 to 152.70 μg N kg[U+203E]1 d[U+203E]1) were 30 to 65 times higher than Dr(in situ) measured without pre-conditioning (2.76 and 2.28 μg N kg[U+203E]1 d[U+203E]1). In situ denitrification rates measured in the NO_3[U+203E]-free zone were only comparable with laboratory denitrification rates after pre-conditioning, otherwise Dr(in situ) strongly underestimated Dr(365). Without pre-conditioning, push-pull tests in the NO_3[U+203E]-free zone of the FFA exhibited an exponential increase of denitrification rates during the tests. We interpret this as microbial adaptation processes. After pre-conditioning an exponential increase of denitrification rates was not observed.
We propose that pre-conditioning prior to subsequent push-pull tests is a prerequisite for estimating the stock or reactive compounds from Dr(in situ) in the NO_3[U+203E]-free zone of aquifers. But further research is needed to evaluate microbial adaptation processes during push-pull tests.

References:
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