Geophysical Research Abstracts
Vol. 18, EGU2016-6358, 2016
EGU General Assembly 2016

Field experiments to evaluate nitrate-leaching from drained agriculturally used areas

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Agricultural land use is one of the main sources for diffuse nitrogen (N) inputs into surface- and groundwater. To fulfill the objectives of the European water protection policy it is mandatory to optimize agricultural management and to adopt it to site specific conditions. N present in soil is dominated by organic N, and after mineralization inorganic plant available N, obtaining the components ammonia and nitrate (NO_3-N). In the environment, NO_3-N occurs as the negatively charged ion NO_3- which is generally solved. Thus, NO_3-N is the major N-species in waters, whereas its transport is directly influenced by the flow regime. In dependence of soil type and meteorological conditions, subsurface drainage was often installed to prevent water logged zones as a requirement for agricultural use. But drainage systems were often discussed as one of the main sources for NO_3-N inputs into surface water due to temporary high discharge rates and short residence time of soil water resulting in limited conditions for NO_3-N degradation via denitrification.

In the study presented herein, two adjacent tile-drained agriculturally used areas with adjusted agronomic conditions but different soil properties were investigated regarding their flow regime and their N-kinetic from 11/1/2013 until 10/31/2015. Both fields obtained the same size and drainage network (drain depth 0.8 m, gab distance 10 m). Field I was influenced by confined groundwater conditions due to an alternating strata of sandy and loamy layers. Field II was impermeable from a depth of one meter, showing a backwater influenced flow regime. The temporal course of soil moisture (35, 60 and 85 cm depth), drain rate as well as ground- and backwater head was registered continuously at both sites. Furthermore NH4-N- and NO_3-N-concentrations (cNO_3-N) in each compartment were measured.

The experimental results showed that field I revealed significantly lower discharged drain rates and NO_3-N-loads (17.1 mm and 2.5 kg N/ha) compared to field II (150.1 mm and 40.3 kg N/ha) within the observation period. As expected the amount of discharged NO_3-N increased with increasing drain rate. But a significant feature was the temporal course of registered cNO_3-N at both fields. Mean cNO_3-N in drain water of field II, was generally high during the whole observation period (mean: 22.8 mgN/l), corresponding to registered cNO_3-N in backwater with 23.2 mgN/l. At field I, however, mean cNO_3-N in drain water was only 4.5 mgN/l, whereas only a peak wise arise in concentration could be measured after rain events corresponding to higher discharge rates. Additionally, groundwater showed low NO_3-N concentrations of only 1.1 mgN/l. These differences resulted mainly due to different soil hydraulic properties. At field II drain water consisted only of percolating seepage water whereas a small denitrification potential could be assumed. At field I however, drain water was a combination of groundwater, obtaining a higher denitrification potential, and after rain events seepage water, which was generally enriched with NO_3-N.

The investigations showed the need to consider small scale soil heterogeneity due to the fact that not only the flow regime but also the N-kinetic was influenced significantly.