ABSTRACT

A two-year field-scale study was carried out in twelve 30 m^2 plots during Kharif (June to October) of 2004 and 2005 to investigate water flow and nitrogen transport and transformation processes in lowland paddy field. Three nitrogen treatments (T1: 80, T2: 160, and T3: 240 kg N/ha in form of urea) with four replications were laid out in a completely randomized design. Water and nitrogen dynamics in these experimental plots were studied by measuring pressure heads and concentrations of nitrogenous fertilizer ions at different soil depths during the entire paddy growth period. Soil hydraulic properties of experimental plots were estimated by three different field methods. Time series data of piezometric (pressure) heads were used to optimize soil hydraulic properties for each soil layers in twelve different plots in Method-I. In Method-II and III, cumulative infiltration volumes from double ring infiltrometer and tension disc infiltrometers were used, respectively, to optimize these parameters. The simulation environment of HYDRUS-1D was employed for data analysis. Solute transport and nitrogen transformation parameters of different soil layers were optimized from simultaneous simulation of NH_4-N and NO_3-N concentration using SPM and DPM. Soil bulk density (ρ_b) values measured in four soil layers from different experimental plots and simulation results supported the presence of a compacted soil layer (plow sole) at a depth of 10-26 cm soil depth. The compacted plow sole in our study had a larger hydraulic conductivity than those published in literature. Another typical feature of this soil is the presence of a discontinuous clay pan at a depth of about 1 m. The presence of two compacted layers within the top 100 cm of soil promote the formation of two temporary perched water tables in puddled paddy fields in our experimental site. Thus, the soil profiles in the experimental site were considered to have four distinct soil horizons. This study demonstrates that piezometric heads can be used to model water flow in lowland paddy field either using the single- or the dual-porosity model although the later provided a better description for about 50% of cases. Even a single growing season of monitoring could provide a set of *in situ* hydraulic properties that may be used for predicting soil water regime in the lowland paddy fields. High NH_4-N concentrations was found compared to NO_3-N concentration which is an indication of slow nitrification and rapid denitrification as is expected under the anaerobic soil environment in paddy fields. NH_4-N and NO_3-N breakthrough curves (BTCs) showed some degree of fluctuation at different soil depths. A mix of transient soil water regime and inherent variation in soil properties might cause fluctuating NH_4^+

and NO_3^--BTCs. Results from single- and double-porosity modeling approaches were compared and were found that both the models could simulate water and solute transport considerably well. Although the DPM approach did not improve water simulation in submerged paddy field but it could better describe NH_4-N and NO_3-N transport over SPM in several cases. Field average solute transport and reaction parameters estimated from both the models were found in the similar range. Dispersivity of soil layers were found increasing with soil depth. Nitrification rate constant and denitrification rate coefficient was found high for top soil layers and decreased with soil depth. Denitrification rate coefficient was found high in comparison to nitrification rate coefficient in respective soil layers. Leaching of NH_4-N was always found high compared to NO_3-N in both the years. Nutrient uptake pattern among three fertilizer treatments were found highest for plots under T2 followed byT3 and T1. Simulation results showed that degradation rate of nitrogenous fertilizer in deeper layer was less due to less microbial activity and therefore significant leaching of N below root zone have potential threat to contaminate shallow groundwater and eventually to deep groundwater system in locality.

Keywords: Preferential flow, paddy soil, plow sole, soil hydraulic properties, nitrogen transformation, breakthrough curve, leaching, HYDRUS-1D