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Variability in nitrate fluxes under agricultural fields – implications from direct observation in deep vadose zone

Gal Weissman (1), Golan Bel (2), Alon Ben-Gal (3), Uri Yermiyahu (3), and Ofer Dahan (1)

(1) The Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, (2) Department of Solar Energy and Environmental Physics, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, (3) Soil, Water and Environmental Sciences, Agricultural Research Organization, Gilat Research Center

Excess use of nitrogen fertilizers in agriculture often leads to accumulation of nitrate in the unsaturated zone and to groundwater pollution. There is an uncertainty regarding the spatial variability in fertilizer transport and uptake efficiency as a result of the lack of studies focusing heterogeneous vadose zone transport based on continuous non-destructive measurements. An experimental field site on loess soil in a semi-arid climate in the northern Negev in Israel hosts a commercial rotation of field crops and 4 treatments of fertilization (nitrogen) level and irrigation salinity. Plots are alternatively applied with conventional or increased nitrogen amount and normal or increased salinity. The impact of the various treatments on solute and nitrate transport below the root zone is monitored by a Vadose zone Monitoring System (VMS) that was installed in the unsaturated zone under each plot. The VMS provides long term continuous measurements by moisture sensors and pore water sampling ports that are distributed across the unsaturated soil profile at depths of 1 to 4.5 m. A bromide tracer solution was applied at the beginning of the experiment in order to characterize the transport of solutes. Preliminary results show that nitrate accumulation and transport in the soil varies greatly in time and space as expected, and that most of the deep transport occurs in response to large irrigation and precipitation events. Additionally, treatment of irrigation with higher salinity water resulted in an apparent effect on the velocity and depth of infiltration. Using a new modeling approach, multiple 1D simulated profiles (using HYDRUS) were calibrated separately in reference to each monitored point across the unsaturated zone. Altogether, 56 measurement points, composed of 24 moisture sensors and 32 sampling ports, provided data for 56 simulated profiles thus enabling weighting of the soil characteristics. The combination of continuous deep vadose zone measurements with calibrated simulations based on those measurements enabled the characterization of the variability using the characteristics of the flow and transport directly instead of pre-estimating the variability explicitly. This, in turn, allowed the weighting of possible solute fluxes. Characterizing the variability in nitrate fluxes should promote efficient use of nitrogen fertilizers and thereby reduce groundwater pollution by nitrate.