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Modelling nitrate from land-surface to wells-perforations under Mediterranean agricultural land: success, failure, and future scenarios

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Contamination of groundwater resources by nitrate due to leaching under agricultural land is probably the most troublesome agriculture-related water contamination, worldwide. Deep soil sampling (10 m) were used for calibrating vertical flow and nitrogen-transport numerical models of the unsaturated zone, under different agricultural land uses. Vegetables fields (potato and strawberries) and deciduous (persimmon) orchards in the Sharon area overlaying the coastal aquifer of Israel, were examined. Average nitrate-nitrogen fluxes below vegetables fields were 210-290 kg ha-1 a-1 and under deciduous orchards were 110-140 kg ha-1 a-1. The output water and nitrate-nitrogen fluxes of the unsaturated zone models were used as input for a three dimensional flow and nitrate-transport model in the aquifer under an area of 13.3 square kilometers of agricultural land. The area was subdivided to 4 agricultural land-uses: vegetables, deciduous, citrus orchards and non-cultivated. Fluxes of water and nitrate-nitrogen below citrus orchards were taken from a previous study in this area (Kurtzman et al., 2013, j. Contam. Hydrol.). The groundwater flow model was calibrated to well heads only by changing the hydraulic conductivity while transient recharge fluxes were constraint to the bottom-fluxes of the unsaturated zone flow models. The nitrate-transport model in the aquifer, which was fed at the top by the nitrate fluxes of the unsaturated zone models, succeeded in reconstructing the average nitrate concentration in the wells. On the other hand, this transport model failed in calculating the high concentrations in the most contaminated wells and the large spatial variability of nitrate-concentrations in the aquifer. In order to reconstruct the spatial variability and enable predictions nitrate-fluxes from the unsaturated zone were multiplied by local multipliers. This action was rationalized by the fact that the high concentrations in some wells cannot be explained by regular agricultural activity, and are probably a result of some malfunction in the well area. Prediction of the nitrate concentration 40 years to the future with 3 nitrogen-fertilization scenarios showed the following: 1) under “business as usual” fertilization scenario, the NO_3 concentration will increase in average by 19 mg l-1; 2) In reducing 25% of the nitrogen fertilization mass scenario, the nitrate concentration in the aquifer will stabilize; 3) In reducing 50% of the nitrogen fertilization mass scenario, the concentration will decrease in average by 18 mg l-1.