A stochastic method for simulation of leaching in soil

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A model has been developed for the purpose of simulating the leaching of non-adsorbed solutes through soil for any initial distribution of the water and the solute in the soil, and for any pattern of water and solute addition or subtraction through time. A model with these capabilities is required for for simulation of the response of plants to nitrogen in a leaching environment.

Methods

Solute is represented by the model as a number of discrete packets of a stated size, each of which has an exact location in the soil. In each time step, new locations are calculated for each of the packets according to an arbitrary probability function and the amount of movement of the solution.

Water in the model is assumed to come to equilibrium in each time step. If water is added, the depth to which the soil will be wetted to field capacity is calculated, and a wetting front is established at that point. The depth to which each packet of solute is most likely to move (the peak displacement) is calculated by the distance which the water at the original depth of the packet would move if all water was displaced by the water above and no mixing occurred. The distribution function defines the probability of the packet actually moving to depths above or below the most probable depth. Movement beyond the wetting front or above the soil surface is not allowed.

The model has been used to simulate leaching of soil nitrate and added calcium nitrate through a column of loamy sand soil. The distribution function used was a normal curve with the variance proportional to the peak displacement (i.e. the standard deviation proportional to the square root of the peak displacement). The initial nitrate content of the soil was 1mg N/kg and nitrate was added to the surface at the rate of 160 kg N/ha. The volume simulated was 135 cm in depth by 100 cm^2 surface area. Each packet of nitrate represented 25?g of nitrogen, resulting in 6400 packets from the calcium nitrate and 540 packets from the soil nitrogen.

Results and discussion

Satisfactory agreement was achieved between the model and the measured data. In the measured data, however, the nitrate peak moved slightly more slowly than the water, perhaps because of adsorption, while in the model adsorption was not taken into account.

This style of modelling works completely independently of predefined soil layers, but it can be used in conjunction with layered models of water uptake, or solute removal or production. Any number of solute packets could be added or removed from any depth between leaching time steps and the operation of the model would not be affected. The model could also be used with asymmetrical distribution functions if required. Phenomena such as adsorption could be approximated either by immobilizing a proportion of packets in each step or by scaling the movement of all packets. Three dimensional solute movement would also be possible

The major disadvantage of the Method is a large requirement for computer memory and processor time.