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Simulation of Leaching Nitrate with HYDRUS-1D in Lysimetery Studying Under Wheat Cultivated In Arid and Semi-Arid Conditions of Dezful, Iran

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ABSTRACT
Nitrogen is considered as an essential element for plants. However, its high solubility results in leaching it into soil deep. Due to saving in time and costs, mathematic models are commonly used in simulating some parameters, particularly in water and soil. In this paper, simulation of nitrate mobilization was carried out by HYDRUS-1D model in order to study movements of nitrate in the soils under lysimetery–farmed wheat by sampling and measuring nitrate concentrations within outlet of lysimeters. The results showed that HYDRUS-1D model can simulate nitrate leaching accurately.
Key words: *leaching, nitrate, lysimeter, HYDRUS-1D software*

INTRODUCTION

From the viewpoint of availability of nutrients, shortage of nitrogen is the most important limiting factor for growth of agricultural plants, because plants need it more than any other nutrient [1]. Nitrogen losses is not only economically important (crop output, costs of fertilizers, energy and labor) but nitrogen leaching from soil profiles pollutes the environment and contaminates groundwater, particularly drinking water [2].Donald and Gillian [3] reported that there are nearly 20 models about nitrate mobilization. Most of these models are resulted from field studies and are able to simulate nitrogen at deepest plant roots [3]. Assefa and Chen [4] simulated horizontal movements of nitrous nitrogen in soil following injection of liquid fertilizers. HYDRUS-2D was used to calculate Richard trend and the convection dispersion equation (CDR)[4]. Rezaee Rashti *et al* [5] conducted a research to simulate nitrate leaching under rapeseed lysimeter farming conditions. Regression analysis results suggested that there is a significant correlation between measured levels of leaching and simulation results. Parkin and Lauzon [6] investigate about nitrate leaching in two types of soil with different hydrological conditions using a stationary tracer. In this research, field measurements and HYDRUS-1D model were used for evaluating the quality of annual mobilization of nitrate in two different soil types (B and C) using tracer for measuring chlorine and the amount nitrate leaching during winter [6]. Derakhshan Nejad et al [7] compared direct and reverse model to forecast nitrate movements in soil by using HYDRUS-1D model. This model could show a good estimate of nitrate movements in soil. Radcliffe and Bradshaw [8] applied a nitrogen simulation model for wastewater systems. HYDRUS model is a 2-and 3-dimensional optional program, which variably saturates the flow chart. The state and mobilization of various types of nitrogen in drains and soils around a wastewater treatment plant are predicted by using model [8]. The aim of the present research is simulation of mobilization of nitrate in soil using HYDRUS-1D.

MATERIALS AND METHODS

In order to estimate the nitrate nitrogen leaching at the root zone, wheat nitrate leaching was conducted in 9 lysimeters with 90cm high and 30cm in diameter at Islamic Azad University, Dezful branch farmland, with a completely randomized design and three replications, in agricultural year 2011-2012. Treatments include three types of irrigation water: Common

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irrigation water as normal irrigation or control treatment municipal treated wastewater with nitrogen concentration of 50mg/L municipal treated wastewater with nitrogen concentration of 25mg/L. In lysimeters which were under normal irrigation, Potassium Nitrate was added to soil as a basic fertilizer before plantation, and nitrogen fertilizer in two phases, after plantation. Containers were placed under lysimeters' outlet in order to measure nitrate content of drainage after irrigation. Every ten days a sample of drainage collected after irrigation. After each sampling and immediate transfer to laboratory, nitrate content of drainage outlets were measured. Nitrate content of drainage was measured using spectrophotometer at a wavelength of 420nm and according to phenol disulfonic method. You can find soil and sewage properties in tables 1 and 2.

Table 1- Some properties of the soil

Soil texture	Ec	Soil total nitrogen	Phosphorus	Potassium	pH	Organic matter
Clay loam	1.4	16	35	245	7.9	6

Table 2- Some chemical properties of the municipal treated wastewater

Organic matter	pH	Potassium	Phosphor	Total nitrogen	EC
1.1	7.9	26.2	11.5	25	**3.1**

Finally, the obtained results of HYDRUS-1D model were analyzed and statistical analysis was performed by Excel and SPSS. The required parameters to simulate nitrate movements by HYDRUS-1D model include: soil texture, apparent special mass, primary levels of nitrogen in soil, primary humidity of soil, amount of irrigation water, amount of nitrogen fertilizers, date of application, evapotranspiration, maximum height of overlying water.

RESULTS AND DISCUSSION

In order to simulate nitrate in drain waters, nitrate was used in two concentrations of 25mg/l and 50mg/l, respectively. Figures 1 and 2 shows nitrate movements based on a comparison of the measured and observed data. To calibrate the model, control data were used. According to the observed data, it can be concluded that nitrate movements in soil had a descending trend as the time passes and the model could display this trend in a good manner.

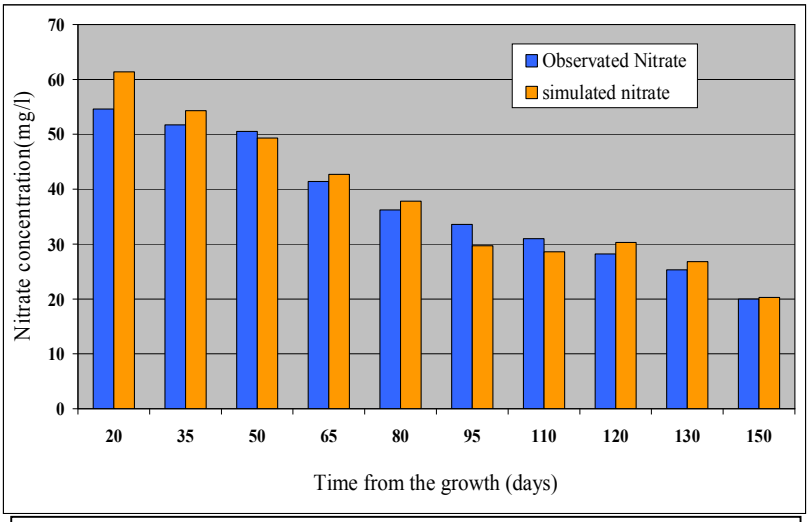

Figure 2. Simulation of nitrate movements within lysimeters irrigated with wastewater containing 50mg/l nitrogen

To assess precision of the model R^2 correlation coefficient was used. As it is shown in figures 3 and 4, R^2 correlation coefficient in concentration of 25 mg/l and 50 mg/l were 0.97 and 0.95, respectively. Figure 3 shows Schematic comparison of simulation and observation amounts of

nitrates (mg/l) and calculation of R^2 correlation coefficient in lysimeters irrigated with wastewater containing 25mg/l nitrogen concentration.

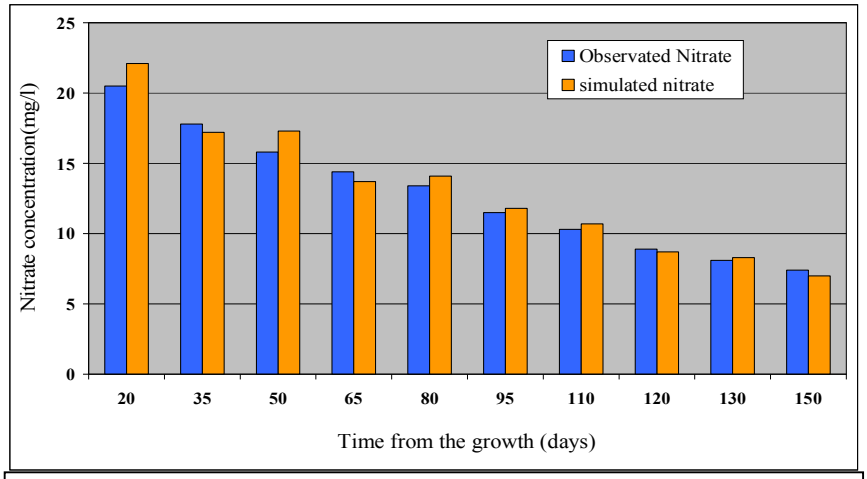

Figure 2, Simulation of nitrate movements within lysimeters irrigated with wastewater containing 25mg/l nitrogen

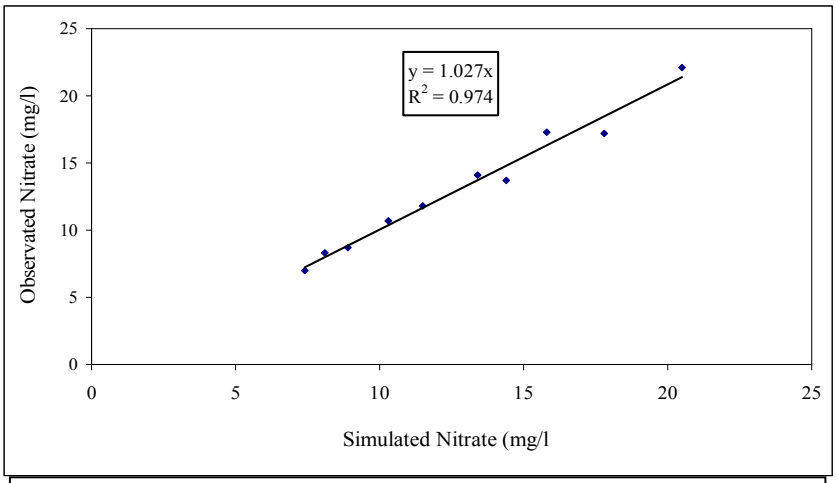

Figure 3- R^2 correlation coefficient in concentration of 25 mg/l

Figure 4.Schematic comparison of simulation and observation amounts of nitrates (mg/l) and calculation of R^2 correlation coefficient in lysimeters irrigated with wastewater containing 50 mg/l nitrogen concentration.

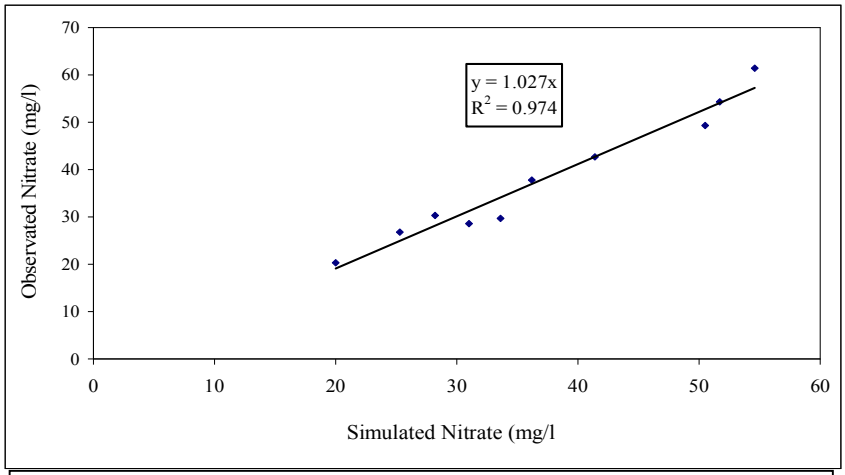

Figure 4- R^2 correlation coefficient in concentration of 50 mg/l

CONCLUSION

HYDRUS-1D model is able to stratify soil profile with regard to physical and chemical properties of soil, predict concentration of nitrate in pre-determined time intervals and in different depths of soil profile by using a set of required input parameters and determination of boundary conditions and primary levels for water flow and salts in each stratum, and simulate the mass of nitrate leached from soil profile based on a predefined time unit for the model. High correlation coefficient (R^2= 0.95, 0.97) for the observation data compared to the data simulated by HYDRUS-1D indicates high precision of this software. Consequently, HYDRUS-1D can simulate nitrate leaching with an appropriate precision.

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