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Monitoring and modelling terbuthylazine and desethyl-terbuthylazine in groundwater.

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Protection of ground and surface water quality is critical to human health and environmental quality, as well as economic viability. The presence of contaminants in groundwater is a common phenomenon and derives from many anthropogenic activities. Among these activities most likely to pollute water resources are the use of fertilizers, pesticides, application of livestock, poultry manure, and urban sludge. Therefore, agriculture results to be a significant contributor to diffuse and point sources of groundwater contamination.
A study was carried out from April 2005 until December 2007 in order to monitor the concentrations of the herbicide terbuthylazine and one of its metabolite, desethyl-terbuthylazine in shallow groundwater. Terbuthylazine is a widely used herbicide for pre-emergence and post-emergence weed control in several crops. The monitoring study was performed in different Italian areas representative of maize crop. These areas resulted to be in the north of Italy, in the Po Valley area. Inside these representative areas a total of eleven farms were identified; each farm had a plot extended for about 10 hectares, cultivated with maize according to normal agricultural practices, with slope not exceeding 5%, uniform direction of groundwater flow, absence of superficial water bodies. In order to sample groundwater, each plot was equipped with four couples of piezometers.
Groundwater samplings were carried out every two months. The results showed that the concentrations of both compounds were in general low, except in a couple of sites, and especially in June and August, the months which follow the treatment, and in October and December, usually rainy months. In general metabolite concentrations were higher than the parent compound.
On one hand a monitoring approach is helpful in order to understand the behaviour of a compound in real conditions; however, on the other hand it gives only an instant picture of the present situation without any prevision about the future. Therefore, after the monitoring study the leaching of terbuthylazine and desethyl-terbuthylazine in groundwater was simulated with the aim to: 1) to verify a possible dilution effect due to lateral recharge; 2) to verify that the sampling time during the monitoring study was appropriate; 3) to verify the leaching of the metabolites in time.
The model MACRO (version 5.1) was used. MACRO is a physically based one-dimensional model, which considers preferential flow (i.e. 'micropores' and 'macropores') to describe the transport of water and solutes in soils. Using the data coming from the monitoring (i.e.: soil, climatic, geology and hydrological data) a scenario was set in each of the eleven Italian sites monitored from 2005 to 2007. A maize monoculture was simulated for 20 years in each site, with a pre-emergence treatment every year.
Daily measurements of groundwater table depth were available for each site, and then these data were used in order to reach a good calibration of the soil hydrology. Two sets of soil data were used: soil data acquired from the analysis of the soil core sampled in each site and soil data of the corresponding reference profile obtained from the regional soil maps. Furthermore, in order to estimate soil hydraulic parameters, two sets of pedotransfer functions were used: one developed for the northern Europe soils and one developed for the Po Valley soils.
The results showed that the groundwater table depth simulated fitted quite well with the measured data, and then it was demonstrated that the groundwater recharge was constant in time. Only in one site measured and simulated groundwater table depth did not match to each other. This case suggested that hydrological equilibrium was not given only by precipitation/irrigation and evapotranspiration, then lateral or bottom recharge and a consequent dilution effect were assumed. Furthermore, in order to estimate the lateral recharge "Darcy's Law" was applied and it was demonstrated that the lateral recharge was rather null in all sites except one, however for all sites it resulted that the two months sampling time was satisfactory in order to avoid dilution effect.

Moreover, no particular differences resulted among the simulations with reference soil data and soil core data. Therefore, using the reference soil data the model can be applied to wider areas. In addition, no particular differences were shown in using the two different PTFs.
Finally, the leaching of the parent compound and its metabolite in time was simulated and the estimated concentrations were compared with the measured ones.
The ability to assess the environmental impact of pollutants at local, regional and global scales on a real time and predictive basis is a key component to achieving sustainability of the environment and agriculture.