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Coupling transfer function and GIS for assessing non-point-source groundwater vulnerability at regional scale

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Non-point source (NPS) pollution in the vadose zone is a global environmental problem. The knowledge and information required to address the problem of NPS pollutants in the vadose zone cross several technological and sub disciplinary lines: spatial statistics, geographic information systems (GIS), hydrology, soil science, and remote sensing. The main issues encountered by NPS groundwater vulnerability assessment, as discussed by Stewart [2001], are the large spatial scales, the complex processes that govern fluid flow and solute transport in the unsaturated zone, the absence of unsaturated zone measurements of diffuse pesticide concentrations in 3-D regional-scale space as these are difficult, time consuming, and prohibitively costly, and the computational effort required for solving the nonlinear equations for physically-based modeling of regional scale, heterogeneous applications.

As an alternative solution, here is presented an approach that is based on coupling of transfer function and GIS modeling that:

a) is capable of solute concentration estimation at a depth of interest within a known error confidence class;

b) uses available soil survey, climatic, and irrigation information, and requires minimal computational cost for application;

c) can dynamically support decision making through thematic mapping and 3D scenarios

This result was pursued through 1) the design and building of a spatial database containing environmental and physical information regarding the study area, 2) the development of the transfer function procedure for layered soils, 3) the final representation of results through digital mapping and 3D visualization. One side GIS modeled environmental data in order to characterize, at regional scale, soil profile texture and depth, land use, climatic data, water table depth, potential evapotranspiration; on the other side such information was implemented in the up-scaling procedure of the Jury's TFM resulting in a set of texture based travel time probability density functions for layered soils each describing a characteristic leaching behavior for soil profiles with similar hydraulic properties. Such behavior, in terms of solute travel time to water table, was then imported back into GIS and finally estimation groundwater vulnerability for each soil unit was represented into a map as well as visualized in 3D.