

Comparison of Neural Network and Neuro-fuzzy Techniques in Ground Water Vulnerability Mapping: A Case Study

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Abstract

Contamination of ground water (GW) has been a major environmental concern in recent years. However, delineation of vulnerability zones or creation of vulnerability maps is a difficult task due to the inherent uncertainties of the parameters that influence contamination potential of an area. Therefore, development of an affordable but reliable technique to generate a GW vulnerability map at the watershed or county scale will be a useful GW management tool. These maps would help prioritize those wells located in vulnerable areas for testing contaminants and for landuse planning of the future.

Coupling of neural networks (NN) and neuro-fuzzy models with a Geographic Information System (GIS) will facilitate vulnerability mapping of a complex system with enhanced spatial visualization capabilities of the models.

NN are multi-input, multi-output nonlinear models and can represent the complex interactions among the input/output parameters. Although in recent years NN has been successfully used in solving difficult hydrological and environmental problems, it is not possible to determine how the solution was found due to the inherent black box nature of the NN. It is also not possible to insert prior knowledge to a NN.

Neuro-fuzzy models were used in the study because of this inherent capability to deal with uncertainties in the data, tolerate imprecision and extract information from incomplete and contradictory datasets. Neuro-fuzzy modeling is an approach where the fusion of NN and Fuzzy Logic find their strengths and complement each other. This combined approach has self-learning and generalization capabilities and can meet pre specified accuracy level. This approach also allows incorporation of expert's opinion and require less CPU time, thus helps overcome the key problems associated with NN. A fusion of NN and FL provides a system that usually requires less computational power but has the ability to generalize and learn through the convergence of net.

This study aims at comparing the vulnerability maps developed using NN and neuro-fuzzy methods. The research reports a case study of Woodruff County, Arkansas. This County was selected for its extensive agricultural landuse and the presence of underlying alluvial aquifer.

Four variables were used as inputs: Depth to ground water, Recharge of aquifer, Soil media and Impact of vadose zone. These variables were used as inputs for both the models. They were derived from the primary data layers in a GIS. Water quality data from 55 wells were used for validation of the models. The water quality data was

analyzed by the Arkansas Water Resources Research Center (AWRRC) for 13 pesticides/herbicides. Bentazon was the most commonly found contaminant. A set of coincidence reports was generated between vulnerability maps and well contamination data to compare actual contamination with potential contamination (or vulnerability) generated by both models.

Use of neuro-fuzzy techniques reduced the time involved in the process of generating the vulnerability maps. It was also seen that neuro-fuzzy techniques performed better in predicting contaminated wells while NN models showed a better performance for non-contaminated wells.

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